Risks and Feelings: Affective Influences on the Perception of Non-Ionizing Radiation Risks

Thesis
presented to the Faculty of Arts
of
the University of Zurich
for the degree of Doctor of Philosophy

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Accepted in the spring semester 2010 on the recommendation of
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Zurich, 2010

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General Introduction

1. Introduction

Walter Faber is a successful scientist. Logic and statistical reasoning determine his thinking. “I’m a technologist and accustomed to seeing things as they are”, is his credo. He seems to be afraid of nothing in the world. When a viper bites his daughter Sabeth, he accepts this fact with irritating calmness. “Did you know,” he asks Sabeth’s mother Hanna, “that the mortality from snake bites is only three to ten percent?” Hanna, on the other hand, reacts with anger and incomprehension: “You and your statistics! If I had a hundred daughters, and all of them had been bitten by a viper, there would be some sense in it. […] I’ve only got one child.”

What is so irritating about Walter Faber? What makes his reaction so inappropriate? It is probably the fact that Faber, fictitious person and protagonist of Max Frisch’s novel *Homo Faber* (1957), seems to lack a central humane quality: feeling. His exaggerated character of a technologist stands in sharp contrast to Hanna, who seems to react more naturally—and more humanlike. For her, there is no reassurance in the fact that the mortality rate from a snake bite is quite small. It is the possibility rather than the probability that her daughter might die that brings her to the verge of despair. This example highlights that human perception—and risk perception in particular—is determined not only by probability and statistics but also by our fears, worries, and pleasures. There is probably no event or object that we encounter in everyday life toward which we do not experience some immediate feeling—be it a viper, an airplane, or a mobile phone.

Feelings usually occur rapidly, and they can help us to differentiate important from less important information (Damasio, 1994). Feelings can serve as a necessary and fast shortcut to decisions when things are unexpected or unknown (Finucane, Peters, & Slovic, 2003). They can help us to anticipate how we will like the consequences of our actions. And feelings can be a powerful behavior motivator. However, they can also conflict with the knowledge we have gained about certain facts. And feelings can be misleading when the consequences of our actions turn out to be different from what we anticipated (Slovic, Finucane, Peters, & MacGregor, 2002).

The general aim of this work is to examine how feelings influence risk and benefit perceptions, building on various psychological theories that emphasize the importance of feelings in human perception and behavior. Before commencing with this objective, it is essential to define some terms that will emerge consistently throughout the work. The term *feeling* is very prominent in everyday speech and denotes a conscious subjective experience of moods and emotions (Russell, 2003). In psychological research, the term feeling includes affective feelings, such as anger and fear, and non-affective feelings, such as being tired or bored (Clore et al., 2001; Werth & Mayer, 2008). *Affect* simply refers to valence, that is, the positive or negative aspect of things (Clore, Schwarz, & Conway, 1994; Clore et al., 2001). Furthermore, affect is often used as a broad and inclusive label to refer to emotions and moods (Forgas, 1992; Werth & Mayer, 2008). *Emotions*, on the one hand, are high in intensity and short-lived, and they are usually associated with a stimulus object. *Moods*, on the other hand, are understood as relatively low in intensity, diffuse, and relatively enduring and are not usually associated with a stimulus object (Forgas, 1992).

In this work, the role of affect in risk perception will be primarily examined in the context of risks associated with non-ionizing radiation, in particular with mobile communication. Studying the public perception of mobile communication might be challenging for various reasons. First, mobile communication is a relatively new technology. Many people (including experts) are uncertain about its impact on individuals. Little is known about the long-term health effects of the radiation produced by mobile communication. Furthermore, it has been shown that people often fear mobile phone base stations more than their mobile phones, although the actual exposure to radiation can be much higher from mobile phones (e.g., Hutter, Moshammer, Wallner, & Kundi, 2004). It has also been observed that precautionary policies intended to reassure the public (e.g., tightening the exposure limits of base stations by a factor of 10) can lead to an increase rather than a decrease in laypeople’s concerns about mobile communication (Wiedemann & Schütz, 2005). Moreover, because people can neither see nor smell non-ionizing radiation, mobile communication risks are also characterized by a feeling of loss of control. This situation is probably exacerbated by the fact that citizens rarely have the possibility to take part in the decision process about the location of a mobile phone base station, which, in turn, may lead to anger or frustration. Existing literature on risk perception has indicated that affect may serve as a cue for many important judgments, especially when things are complex or ambiguous (cf. Slovic, Finucane, Peters, & MacGregor, 2004). Hence, because of the uncertain, unknown, and uncontrollable characteristics of non-ionizing radiation risks, mobile communication seems to be an appropriate and interesting field in which to study affective influences on risk perception.

In the beginning of the introductory section, important technological information about mobile communication will be given that will be the basis for understanding subsequent sections. Information will be provided about electromagnetic fields in general, and about how mobile phones and mobile phone base stations work and interact. Special focus will be placed on scientific studies that have evaluated the possibility of adverse health effects of mobile communication. In a second step, central theories of risk perception will be presented. How these theories evolved and why and how they apply to the given context will be explained. Because theories that attach prime importance to affect in risk perception are of particular interest for this work, a subsequent section will deal with these theories in more detail. In a subsequent part of the introduction, studies that have examined perception of non-ionizing radiation and mobile communication will be discussed. Based on this discussion, research gaps will be identified. The last part of the introduction provides an overview of the following chapters and the central research questions of this work.

2. Electromagnetic Fields – A Hazard for Human Health?

2.1. Electromagnetic Fields in the Environment

Electromagnetic fields (EMFs) are omnipresent in the environment. The magnetic field of the Earth, for example, is a natural source of EMF. In addition to natural sources, there are various human-made EMFs in our environment. They are generated either intentionally or as by-products of the use of electrical devices and systems (International Commission on Non-Ionizing Radiation Protection [ICNIRP], 2009). X-rays, electric and magnetic fields from high-voltage power lines, and micro- and radiowaves are examples of artificially generated EMFs. EMFs are characterized by their frequency or their corresponding wavelength. The frequency denotes the number of oscillations or cycles per second. The wavelength describes the distance between one wave and the next (World Health Organization [WHO], 2009). Some electromagnetic waves of higher frequency carry so much energy that they are able to detach electrons from atoms or molecules; thus, the waves create ions. This ionizing radiation includes, for instance, x-rays or nuclear power plant fuel. Most of the human-made sources of EMFs, however, are *non-ionizing fields* or *non-ionizing radiation*; they are characterized by a relatively long wavelength and low frequency. Figure 1.1. illustrates the electromagnetic spectrum, which is typically divided into non-ionizing and ionizing radiation.

The part of the electromagnetic spectrum that refers to non-ionizing radiation is divided into low- and highfrequency fields, infrared radiation, visible light, and ultraviolet radiation (Bundesamt für Umwelt, Wald und Landschaft [BUWAL], 2005).

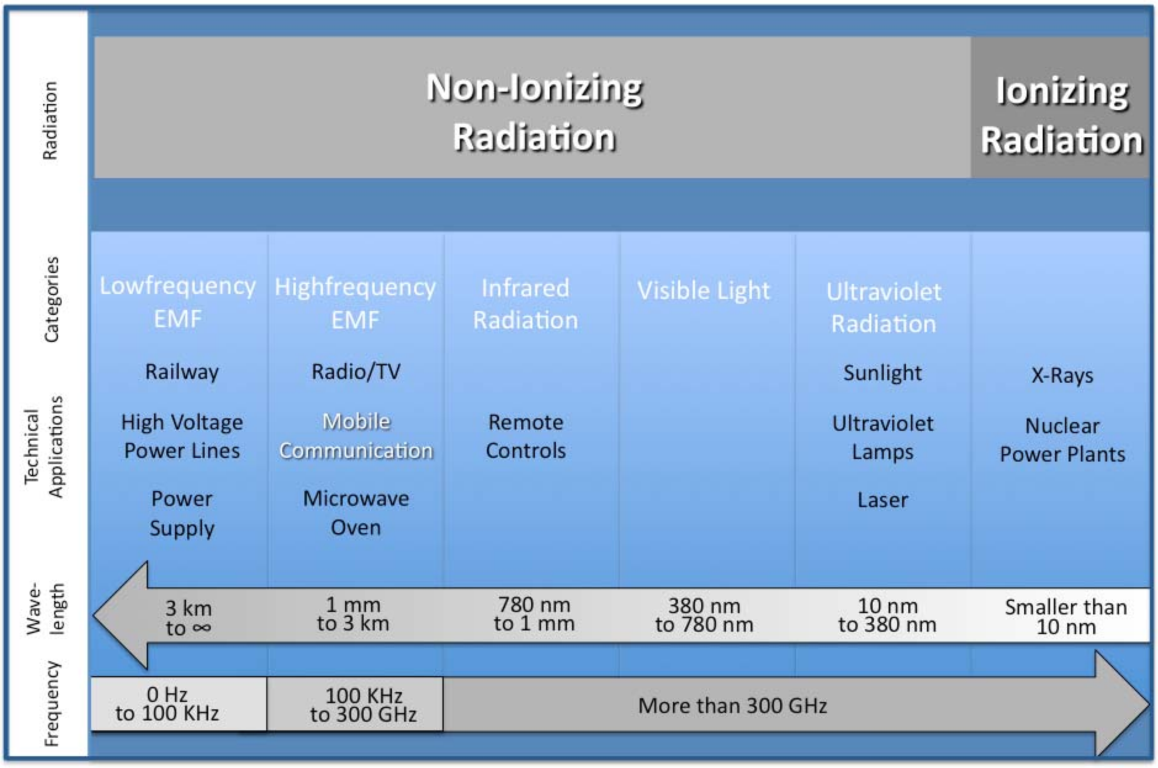

Figure 1.1. The electromagnetic spectrum. Data source: BAG (2000).

Lowfrequency fields are produced by electric and magnetic fields from railway contact lines, high voltage power lines, and home appliances. Power lines, for example, have a frequency of 50 Hz, or 50 oscillations per second (BUWAL, 2005). High-frequency fields are defined as fields with a frequency above 100 kHz (Bundesamt für Gesundheit [BAG], 2000). Because this part of the spectrum is used for radio and television broadcasting, it is also called radio frequency (RF; ICNIRP, 2009). Radar or medical devices such as magnetic resonance imaging are additional examples of RF fields. Frequencies beyond 300 GHz belong to infrared radiation.

2.2. Mobile Communication

Mobile communication is also part of the RF spectrum. The mobile phone and the base station act as an antenna and as a sender. When a phone call is made, the mobile phone converts the voice into electronic signals, which are sent to the base station. When the phone is in ready or standby mode, the phone receives control signals from the nearest base station and updates the network every 20 to 60 minutes about the phone’s location (BUWAL, 2005).

The transmission power of mobile phones is considerably lower than the power of mobile phone base stations. However, the exposure from mobile phones can be much higher, because mobile phones operate close to the phoning person, while people rarely find themselves within close range of a mobile phone base station (BUWAL, 2005; Röösli & Rapp, 2003). Furthermore, in contrast to base stations, the exposure from mobile phones is concentrated on the head. Especially when a phone call is established, the radiation emitted by the mobile phone increases. This is also true when a person is traveling while phoning: the mobile phone always connects to the nearest base station, and radiates with full power for a short duration again when a new base station is found (Röösli & Rapp, 2003). Exposure from a mobile phone also increases when the phoning person is inside a building, because walls and roofs attenuate radiation. In addition, radiation decreases with the inverse square of the distance from the source (cf. Cousin & Siegrist, 2010b). When a phoning person is far away from the next mobile phone base station, the mobile phone therefore has to increase its output power to ensure network coverage.

2.3. Studies on Adverse Health Effects

The ongoing growth of mobile communication and other technologies (Hilty, Som, & Kohler, 2004) also gives rise to public concerns about potential health effects regarding non-ionizing radiation. At the same time, the number of studies investigating causal relations between RF exposure and adverse health effects on humans is constantly growing. As noted by Ahlbom and colleagues (Ahlbom et al., 2009), the literature on this topic has more than doubled within the last 5 years. Therefore, reviews that evaluate, summarize, and interpret these studies have become more and more important.

The European Commission's independent Scientific Committee on Newly Identified and Emerging Health Risks (SCENIHR) collected and assessed epidemiological, animal, and in vitro studies for their latest report on *Health Effects of Exposure to EMF* (SCENIHR, 2009). They note that most reviewed studies are concerned with the question whether RF field exposure leads to an increase in cancer. SCENIHR concluded that exposure to RF fields is unlikely to lead to carcinogenesis. However, they stated that further studies are necessary to identify whether persons who have used mobile phones for more than 10 years have an increased cancer risk. According to the SCENIHR, there is some evidence that RF fields can influence EEG patterns and sleep in humans, although the mechanisms that may explain possible effects on sleep and EEG are largely unknown.

The latest review of the International Commission for Non-Ionizing Radiation Protection summarized epidemiologic evidence on mobile phone use and risk of brain and other tumors (ICNIRP, 2009). They conclude: “In our opinion, overall the studies published to date do not demonstrate a raised risk within approximately 10 years of use for any tumor of the brain or any other head tumor” (p. 357). In this review, the authors pay attention to methodological problems, such as selective nonresponse, inaccuracy and bias in recall of phone use, and exposure misclassification. For example, a self-report of the preferred side of mobile phone use might be prone to reporting bias: If people believe that mobile phone use may have caused their tumor and are retrospectively asked about their preferred side, they might over-report mobile phone use on the tumor side. As in the report of SCENIHR, it is noted that there are only limited data on long long-term use of mobile phones.

According to the WHO, none of the recent scientific reviews has concluded that exposure to mobile phones’ or mobile phone base stations’ radiofrequency fields causes adverse health consequences (WHO, 2000). Regarding cancer, the WHO concludes that the epidemiologic evidence indicates that exposure to RF fields is unlikely to induce or promote cancers. Concerning other effects such as changes in brain activity, reaction times, and sleep, the WHO notes that these effects are small and have no apparent health significance. However, the WHO notes that various studies have demonstrated that the use of a mobile phone when driving increases the risk of traffic accidents. In sum, the reports acknowledge the lack of long-term research, which is needed to assess health consequences of mobile phone use that exceeds 10 years. But according to WHO, SCENIHR, and ICNIRP, it is unlikely that RF constitutes a severe risk to human health within 10 years of use.

However, the public perception of risks can sometimes diverge from the experts’ opinion on the same risk. The next section deals with the question why experts and laypeople often disagree when it comes to perceived levels of risk.

3. Determinants of Risk Perception

3.1. The Psychometric Paradigm

From a technological point of view, risk is a multiplication of two factors: magnitude of harm times probability (Sandman, 1993). Most people, however, do not rely on this formal definition of risk; they rather use intuitive risk judgments called risk perceptions (Slovic, 1987). Early studies on risk perception were aimed at developing a taxonomy for hazards that may help to understand why people perceive different risks differently and that might help to predict responses to risks. More precisely, these studies were aimed at explaining why some hazards were rejected or dreaded while others risks are perceived with indifference, and why public reactions and opinions of risks sometimes diverge from the experts' point of view. The *psychometric paradigm* is presumably the most common and influential approach in order to develop this taxonomy. Launched by Fischhoff and colleagues in 1978 (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978), this methodology is based on various explanatory rating scales such as the voluntariness of the risk, the immediacy of effect, or the severity of consequences (see Table 1.1. for a complete list of the scales used by Fischhoff et al., 1978).

Table 1.1. Rating Scales Used in the Psychometric Paradigm

Scale	**Wording and Label**
1. Voluntariness of risk	Do people get into these risky situations voluntarily? (1 = *voluntary*; 7 = *involuntary*)
2. Immediacy of effect	To what extent is the risk of death immediate—or is death likely to occur at some later time? (1 = *immediate*; 7 = *delayed*)
3. Risk known to exposed	To what extent are the risks known precisely by the persons who are exposed to those risks? (1 = *known precisely*; 7 = *not known*)
4. Risk known to science	To what extent are the risks known to science? (1 = *known precisely*; 7 = *not known*)
5. Control over risk	If you are exposed to the risk of each activity or technology, to what extent can you, by personal skill or diligence, avoid death while engaging in the activity? (1 = *uncontrollable*; 7 = *controllable*)
6. Newness	Are these risks new, novel ones or old, familiar ones? (1 = *new*; 7 = *old*)
7. Chronic-catastrophic	Is this a risk that kills people one at a time (chronic risk) or a risk that kills large numbers of people at once (catastrophic risk)? (1 = *chronic*; 7 = *catastrophic*)
8. Common-dread	Is this a risk that people have learned to live with and can think about reasonably calmly, or is it one that people have great dread for—on the level of a gut reaction? (1 = *common*; 7 = *dread*)
9. Severity of consequences	When the risk from the activity is realized in the form of a mishap or illness, how likely is it that the consequence will be fatal? (1 = *certain not to be fatal*; 7 = *certain to be fatal*)

Source: Fischhoff et al., 1978.

In the psychometric paradigm, participants are asked to rate a number of activities (e.g., swimming, hunting, skiing) and technologies (e.g., nuclear power, home appliances, power mowers) on each of the rating scales. Many of these scales are correlated with each other: Risks that are uncontrollable are often also perceived as involuntary, and risks that are unknown to science are often new risks. These intercorrelations were analyzed using principal component analysis, which indicated that basically two higher-order factors explain the perception of the risks. The first principal component was labeled *dread risk*. The dread, catastrophic potential, and fatal consequences rating scales were highly correlated with this principal component. The second component was labeled *unknown risk*. It correlates with unknown, newness, and delayed consequences. This two-dimensional solution (the *cognitive map*) was replicated in most studies (Siegrist, Keller, & Kiers, 2005).

Undoubtedly, the psychometric paradigm represents a landmark for research on public risk perception (Bronfman & Cifuentes, 2003). However, the paradigm was also criticized for neglecting individual differences in risk perception (Siegrist, Keller et al., 2005; Siegrist, Keller, & Kiers, 2006). It cannot explain why different people perceive the *same* risk differently, because in studies using the psychometric paradigm, averages are taken across all participants. Recent studies have shown that there are substantial individual differences in risk perception. A study designed to explain differences in the perception of food hazards, for example, indicated that individual differences in the cognitive representation of food hazards were correlated with attitudes toward natural foods (Siegrist, Keller, & Kiers, 2006). Little is known about other factors that might account for individual differences in risk perception, and more research is needed to identify these factors.

3.2. Public Outrage

The psychometric paradigm was a starting point for other models that tried to explain why public perception of risks often diverges from a formal risk assessment. Peter Sandman (1987, 1993) based his theory of *public outrage* on the scales suggested by the psychometric paradigm. Sandman proposed 12 so-called outrage factors, which were derived from the psychometric model (see Table 1.2. for an overview of the 12 outrage factors). A main difference from the psychometric paradigm is that these outrage factors also take emotional factors into account, such as trust and fairness, in contrast to the psychometric paradigm, which focuses on cognitive factors (Slovic et al., 2004).

According to Sandman’s theory, risk is a function of hazard and outrage (Sandman, 1993). *Hazard* refers to the technical aspect of risk; it is the product of risk magnitude and probability. *Outrage*, on the other hand, refers to the nontechnical aspects of risks; it refers to everything that people are worried about. Outrage “suggests strong emotion but also suggests that the emotion is justified” (Sandman, 1993, p. 7).

Table 1.2. Outrage Factors Proposed by Sandman (1993)

Low Outrage	**High Outrage**
Voluntary	Coerced
Natural	Industrial
Familiar	Exotic
Not memorable	Memorable
Not dreaded	Dreaded
Chronic	Catastrophic
Knowable	Unknowable
Individually controlled	Controlled by others
Fair	Unfair
Morally irrelevant	Morally relevant
Trustworthy sources	Untrustworthy sources
Responsive process	Unresponsive process

Source: Sandman, 1993.

These outrage factors give important information about why people sometimes act apathetic in face of a serious hazard, or, in contrast, why they seem to be excessively alarmed about a certain risk. Voluntariness, for instance, is an important factor that determines outrage: if a behavior is voluntary, such as smoking, it is more acceptable than if it is coerced, such as second-hand smoking. Another outrage factor is the distinction between natural and industrial. People usually underestimate natural risks, such as the probability of being poisoned by spoilt food, and overestimate risks from industrial products such as food additives. Fairness is another important variable for public outrage: when people believe they have to bear more costs or fewer benefits than others, it will lead to high outrage. Likewise, outrage is high when a source is untrustworthy, for example, when citizens find out that a company or an agency has understated a risk. Thus, the outrage model has strong implications for risk communication, because policymakers need to address these outrage factors when informing the public.

3.3. The Social Amplification of Risk Framework

Other prominent approaches to risk perception and communication have adopted an anthropological framework (Cultural theory; cf. Douglas & Wildavsky, 1982) or a social constructionism approach that considers risk as social construct (cf. Glendon, Clarke, & McKenna, 2006). A theory that combines various approaches is the *social amplification of risk framework* (cf. Kasperson et al., 1988; Renn, Burns, Kasperson, Kasperson, & Slovic, 1992). It is an integrative framework based on the idea that hazards interact with psychological, social, institutional, and cultural processes in ways that may amplify public perceptions and responses to risks (Kasperson et al., 1988; Renn et al., 1992). Amplifying in this sense means intensifying and attenuating risk signals.

Risks and risk events, which include routine or unexpected releases, accidents, discoveries of pollution incidents, reports of exposure, or adverse consequences, are considered signals in this framework. These signals are processed and interpreted by social groups and individuals, which act as amplification stations. News media, risk-management institutions, public agencies as well as the scientists who conduct and communicate the technical assessment can serve as amplification stations. They pass these interpretations on to other groups and individuals, who also engage in amplification and attenuating processes. This social amplification of risk will then lead to risk-related behavioral responses, which will result in secondary and subsequent impacts (i.e., *ripple effects*). Such second- and higher-order impacts include enduring mental perception, repercussions on other technologies, or political and social pressure, and they might trigger or hinder forces for risk reduction.

The social amplification of risk framework is a comprehensive theory that describes the dynamic social processes underlying risk perceptions (Pidgeon, Kasperson, & Slovic, 2003). In this approach, risk events are always real, because they are not only an objective threat but also a product of culture and social experience. An example of a social amplification effect is the H5N1 virus, also known as bird flu. Experts assessed the risks of a pandemic human influenza strain as relatively small (Ferguson, Fraser, Donnelly, Ghani, & Anderson, 2004). While regular seasonal influenza usually kills hundreds of thousands of people per year, the total number of deaths due to H5N1 was 141 in 2006 (WHO, 2006). Yet several amplification stations such as the news media exerted a strong influence on public perception. These ripple effects manifested themselves not only in the public fear of a new pandemic that could kill millions of citizens but also in economic consequences, e.g., a significant loss of poultry sales in Greece and Italy (Bio Economic Research Associates, 2006).

Despite the integrative and comprehensive approach, the social amplification of risk framework has also come under criticism because little attention has been paid to the specific mechanisms that might explain the social forces described in the theory. Sunstein (2002) complemented the framework by suggesting that reputational and informational influences, as well as group polarization, might explain why people come to fear or underestimate certain hazards. Furthermore, the social amplification of risk framework was also criticized for the lack of predictive power necessary to increase the understanding of the dynamics of risk impacts and how they can be altered by risk communication (Pidgeon et al., 2003).

4. The Role of Affect in Risk Perception

4.1. Risks as Feelings

Although affective evaluations of risks were acknowledged by some early researchers on risk perception (e.g., Sandman, 1987, 1993), cognitive evaluations are often more central to risk perception theories. Affective evaluations, however, often occur more rapidly (LeDoux, 1996; Zajonc, 1980) and may influence cognitive assessments of risk and benefit more directly than cognitive evaluations. A model that acknowledges the role of affect experienced at the moment of decision making is the *risk as feelings* hypothesis proposed by Loewenstein and colleagues (Loewenstein & Lerner, 2003; Loewenstein, Weber, Hsee, & Welch, 2001). The authors criticized that virtually all theories of choice under risk and uncertainty are cognitive and consequentialist. The consequentialist perspective assumes that an individual makes decisions based on an assessment of the consequences of possible choice alternatives and chooses those alternatives that maximize the utility of their consequences. Furthermore, according to the consequentialist perspective, feelings are only of minor importance. They are not seen as integral to the decision process; rather, feelings are considered an epiphenomenon. Advocates of the risk as feelings hypothesis, in contrast, argue that emotional reactions often drive behavior, and that emotional reactions to risky situations often diverge from cognitive assessments of those risks. Central to the risk as feelings model is the distinction between *anticipated* and *anticipatory* affect (Albarracín, Johnson, & Zanna, 2005). Anticipated affect consists of predictions about the emotional consequences of decision outcomes. Anticipatory affect, in contrast, refers to the feelings experienced during decision making. The risk as feelings model deals with anticipatory affect and postulates that responses to risky situations result in part from direct affective influences, including emotions such as worry, fear, dread, or anxiety. It is assumed that feelings are sensitive to certain determinants that are not important for cognitive evaluations of risk, such as the vividness with which consequences can be imagined, personal exposure to or experience with outcomes, and past history of conditioning. For example, people who looked at photographs depicting houses in a flooded region perceived greater risk from flooding than participants who looked at neutral photographs (Keller, Siegrist, & Gutscher, 2006) because the vividness of the flood consequences likely evoked specific negative emotions such as fear and worry. According to the risk as feelings model, behavior is determined by the interplay between emotional and cognitive processes. These processes often diverge and have a reciprocal influence on each other.

The risk as feelings hypothesis builds in part on the *affect as information* approach (Schwarz & Clore, 1988), the *somatic marker* hypothesis (Damasio, 1994), and the *affect heuristic* (Alhakami & Slovic, 1994; Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic et al., 2002, 2004). But while these theories focus mainly on the complementary role of cognitive and affective evaluations, the risk as feelings hypothesis assumes that emotions also often produce behavioral responses that depart from what individuals view as the best course of action (Loewenstein et al., 2001).

4.2. The Affect Heuristic

According to the affect heuristic (Alhakami & Slovic, 1994; Finucane et al., 2000; Slovic et al., 2002, 2004), the perception and integration of affective feelings enable us to be rational actors in many important situations. In this sense, affect can serve as a source of information in its own right. It is assumed that individuals use affect as a shortcut within decision making because this is more efficient and easier than weighing all available pros and cons of different options—especially when decisions are complex or mental resources are limited (Slovic et al., 2002).

Influenced by dual process models proposed by Epstein (1994), Sloman (1996), and others, the affect heuristic framework distinguishes two modes of thinking: the analytical system and the experiential system. The analytical system uses algorithms and normative rules, formal logic, and evidence. This system is relatively slow and effortful, and requires conscious control. The experiential system is intuitive, fast, mostly automatic, and not very accessible to conscious awareness. This system relies on images, metaphors, and narratives, and it is linked by experience to affect. According to this, all of the images in people's minds are tagged or marked to varying degrees with affect. It is assumed that an *affect pool* contains these positive and negative markers associated with the images, and the markers differ in regard to their intensity. Rational decision making requires integration of the experiential system and the analytical system, because both have advantages, disadvantages, and limitations. Table 1.3. contrasts the analytical system with the experiential system.

Table 1.3. The Experiential System and the Analytic System

Experiential System	**Analytic System**
1. Holistic	1. Analytic
2. Affective: pleasure-pain oriented	2. Logical: reason oriented (what is sensible)
3. Associationistic connections	3. Logical connections
4. Behavior mediated by “vibes” from past experiences	4. Behavior mediated by conscious appraisal of events
5. Encodes reality in concrete images, metaphors, and narratives	5. Encodes reality in abstract symbols, words, and numbers
6. More rapid processing: oriented toward immediate action	6. Slower processing: oriented toward delayed Action
7. Self-evidently valid: “experiencing is believing”	7. Requires justification via logic and evidence

Source: Slovic et al. (2004).

Research on the affect heuristic has focused on the role of affect in explaining why risks and benefits are inversely related for many people: the greater the perceived benefit, the lower the perceived risk, and vice versa. From an objective point of view, however, risks and benefits tend to be (if at all) positively correlated (Slovic, et al., 2002). Alhakami and Slovic (1994) demonstrated that the perceived inverse correlation between risk and benefit is connected to the strength of affect. If people generally like an activity or a technology, they tend to judge the risks as low and the benefits as high. If they dislike it, risks are judged as high and benefits as low (Finucane et al., 2000). The inverse relationship between risk and benefit increases when people make judgments under time pressure (Finucane et al., 2000). Time pressure might reduce the opportunity for analytic deliberation, allowing affective reactions to exert a dominating influence on judgments (Slovic, et al., 2002).

In the affect heuristic framework, affect serves as important information for judgments and decision options that are unfamiliar to the decision maker. In addition to acting as a conveyor for *information*, three other functions of affect were suggested by Peters, Lipkus, and Diefenbach (2006). Affect further may serve as an attentional *spotlight*, as a *motivator* of behavior, and as a *common currency* for evaluating different options. Affect as spotlight directs attention toward new information, and subsequently, the new information is used to guide the judgment decision. Affect as a motivator promotes information processing and behavioral tendencies. Affect as a common currency allows comparing the values of different decision options or information rather than attempting to make sense out of a multitude of conflicting logical reasons (Peters et al., 2006).

Noteworthy, the affect heuristic framework uses a specific definition of affect. Affect is considered as *goodness* or *badness* experiences as a feeling state, demarcating a positive or negative quality of a specific stimulus. The definition of affect is differentiated from traditional conceptualizations of affect, which define affect as an umbrella term for moods and emotions. According to Finucane and colleagues (Finucane et al., 2003), affect is more subtle than emotion, and has—unlike moods—a direct motivational effect. This conceptualization of affect, however, involves some ambiguity. First, this definition of affect seems to encompass the definition of an attitude (Spence & Townsend, 2008). Second, it is rather unclear how to assess affect in this context. In a systematic study, Peters and Slovic (2007) examined this issue. They arrived at the conclusion that in addition to using a holistic bipolar valenced evaluation measure, further research with affect should include a holistic, unipolar, discrete emotion (HUE) evaluative measure. In other words, affect should be measured using terms that describe discrete emotions such as anger, fear, and happiness. This result calls into question whether affect can be seen as a construct that is independent from other concepts such as emotion or moods. Furthermore, the affect heuristic framework is relatively sparse on how affect evolves and how it can be changed (Spence & Townsend, 2008).

4.3. Concepts Related to Affect: Trust and Implicit Attitudes

Existing literature in risk perception has identified two other concepts that are connected to affect: trust and implicit attitudes. The role of trust in risk perception will be addressed first; subsequently, the concept of implicit attitudes will be illustrated.

Trust is the willingness to make oneself vulnerable to another because of expected beneficial outcomes (Earle, Siegrist, & Gutscher, 2007). The *trust, confidence, and cooperation model* (TCC Model) differentiates between trust and confidence. Both trust and confidence are crucial antecedents of people's willingness to cooperate and to accept new technologies. Confidence is based on experience and evidence, and denotes the belief that certain future events will occur as expected. In contrast, trust is based on social relations, i.e., on shared values. Shared values are inferred from available morality-relevant information. It has been suggested that social trust in responsible intuitions is an important factor influencing affect. Affect may in turn influence judgments of risks and benefits, which may lead to cooperation and acceptance (Siegrist, Earle, & Gutscher, 2007). Evidence for the assumed relation of trust and affect comes from a study on nanotechnology foods and food packaging conducted by Siegrist and colleagues (2007). They demonstrated that social trust in institutions producing nanotechnology foods was an important factor directly influencing the affect evoked by these new products, and the willingness to buy genetically modified foods. However, there is only little research about the direction of the relationship between trust and affect. Affective reactions toward an activity or technology could also shape trust; hence, trust could also be regarded as a specific form of affect (Visschers & Siegrist, 2008). More research is needed to clarify the direction of this relationship.

Recently, affect has also been compared and contrasted with *implicit attitudes* (Spence & Townsend, 2008). Greenwald and Banaji (1995) defined implicit attitudes as "introspectively unidentified (or inaccurately identified) traces of past experience that mediate favorable or unfavorable feeling, thought, or action toward social objects" (Greenwald & Banaji, 1995, p. 8). Implicit attitudes manifest as actions or judgments that are under the control of automatically activated evaluation, and the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) was designed to assess implicit attitudes.

Spence and Townsend (2008) have pointed to the fact that affect as defined by the affect heuristic refers to an attitude, i.e., the *goodness* or *badness* of something. In addition, both the affect heuristic and implicit attitudes are measured in a spontaneous manner. The IAT uses reaction times to measure implicit attitudes; within the affect heuristic, affective influences on risk and benefit perception are stronger under time pressure (Finucane et al., 2000). Furthermore, both constructs are linked to the experiential system described within dual process models. Consequently, it has been suggested that implicit attitudes are virtually equal to the affect pool described within the affect heuristic framework (Spence & Townsend, 2008). The affect heuristic, in this sense, refers then to the active use of this content.

5. Public Perception of Non-Ionizing Radiation

5.1. Psychometric Studies and Public Surveys

Since mobile communication is a rather new technology, mobile phones and mobile phone base stations were not included in early psychometric research. More recent studies, however, have accounted for mobile communication. Siegrist et al. (2005) conducted a mail survey to examine individual differences in risk perception. In this study, participants rated 9 attributes for 26 hazards. In addition to the finding that there were considerable differences among individuals in the cognitive representation of the hazards, it was shown that laypeople assess mobile phones as a new hazard with unobservable consequences. Bronfman and Cifuentes (2003) found that, compared to other risks, technological risks emerged as little known, especially genetic engineering and mobile phone base stations. Taken together, these studies suggest that the risks attached to mobile communication are perceived as little known and moderately dreadful.

In addition to psychometric studies, several public surveys about mobile communication have been conducted. The European Commission regularly conducts a series of surveys across member states (*Eurobarometer*). In 2006, the European Commission carried out a special Eurobarometer on EMF, which involved face-to-face interviews with approximately 30,000 citizens in their homes. The survey found that, in Europe, 48% of the citizens are concerned about the potential health risks of EMF, and most people erroneously believe that the main source of EMF is mobile communication (European Commission, 2007). Furthermore, many citizens feel that they are insufficiently informed on the existing protection framework relating to the potential health risks of EMFs.

Data from a telephone survey conducted in the German- and French-speaking parts of Switzerland have shown that people who use their mobile phones frequently perceived lower risks and higher benefits than infrequent mobile phone users (Siegrist, Earle, Gutscher, & Keller, 2005). Furthermore, no correlation was found between the estimated distance from one’s home to the closest base station and the risks associated with a base station. Another study conducted in Switzerland compared health concerns about mobile phones and mobile phone base stations with health concerns about other environmental risks (Cousin & Siegrist, 2008). The study revealed that mobile communication evokes fewer health concerns than air pollution and ultraviolet rays but evokes concerns similar to those about EMF generated by power transmission lines. In addition, Hutter and colleagues (2004) found that risks from mobile phone base stations were rated slightly higher compared to mobile phones, which was also confirmed by the Eurobarometer.

5.2. Mental Models Approach and Laypeople's Knowledge Gaps

Other researchers have applied the *mental models approach* to explore laypeople's beliefs about mobile communication. The mental models approach builds on the idea that people develop an internal representation of some domain or situation and process new information in the context of their existing beliefs (Morgan, Fischhoff, Bostrom, & Atman, 2002). The approach aims at identifying critical gaps and misconceptions in the cognitive understanding of risks in order to create risk communication messages for laypeople. Morgan and colleagues suggested the following systematic steps to achieve this goal: (1) create an expert model, (2) conduct mental models interviews, (3) conduct structured initial interviews, (4) draft risk communication, and (5) evaluate this communication (Morgan et al., 2002).

Concentrating on the first two steps of the mental models approach, a study by Cousin and Siegrist (2010b) revealed that people from the general population and base station opponents often have knowledge gaps concerning the interaction patterns of mobile phones and base stations. For instance, participants were not aware that the distance from the base station has an influence on the level of EMF emitted by a mobile phone. They further misconceive regulation issues and scientific processes. The prevalence of the revealed misconceptions and knowledge gaps was quantified in a follow-up study (Cousin & Siegrist, 2010a). The mail survey, conducted in the German-speaking part of Switzerland, revealed that questions about the interaction patterns of mobile phones and base stations were correctly answered by only 21% of the respondents. A related task in the questionnaire that used pictogram scenarios confirmed the result that only a few people were aware of the interdependency of mobile phones and base stations and the resulting radiation exposure. Furthermore, the survey showed that participants with knowledge gaps regarding interaction patterns also expressed unfavorable base station siting preferences, i.e., those that would cause more exposure for the phoning population. Laypeople's knowledge also depended on demographic characteristics. Females, respondents older than 50 years, respondents with a low education level, and respondents without an EMF background had significantly less knowledge than males, respondents between 18 and 50 years old, respondents with a high education level, and respondents with a professional EMF background.

A related experimental study investigated how voluntary precautionary recommendations for mobile phone usage influence people's health concerns and behavior (Cousin & Siegrist, 2009). Precautionary recommendations enable users to avoid unneeded exposure. Different versions of a booklet about mobile communication were tested: Some included only technical information; others also contained precautionary recommendations.

Results of the experiment indicated that information per se and not precautionary recommendations influenced the public's perception of mobile communication. After participants read the information, their health concerns regarding mobile phones increased and remained high even after two weeks. In contrast, health concerns in regard to mobile phone base stations decreased significantly after two weeks. The study also examined whether providing information resulted in behavioral changes. Results indicated that the specific precautionary recommendations were effective here: Less behavioral change was found in the group who received a booklet without recommendations. Among those respondents who indicated that they had adopted behavioral changes, most people stated that they had started to avoid holding the mobile phone close to their head when a connection is established.

In sum, the studies that adopted the mental models approach have identified several knowledge gaps and misconceptions of laypeople. In addition, the studies revealed that information about mobile communication might lead to an increase in risk perception and health concerns, especially with regard to mobile phones. For informed decision making by laypeople, this result can be regarded as a positive shift in risk perception, because correct handling of the mobile phone is the most efficient way to reduce exposure from mobile communication radiation.

6. Research Questions and Chapter Overview

So far, research on public perception of mobile communication has primarily focused on cognitive factors. Results of the mental models approach, for example, have shown that people have little knowledge with regard to mobile communication. However, the literature on risk perception strongly suggests that affective variables play a critical role in the perception of risk, too. Trust, fairness, and other affective variables are central in the theory of public outrage (Sandman, 1987, 1993). Likewise, both the affect heuristic and the risk as feelings hypothesis attach prime importance to affect in risk perception (Loewenstein et al., 2001; Slovic et al., 2002). Recently, it has been suggested that implicit attitudes closely resemble the affect pool that is central to the affect heuristic framework (Spence & Townsend, 2008). Little research, however, has measured affect using an implicit measure such as the IAT (Siegrist, Keller, & Cousin, 2006). In addition, the social amplification of risk framework suggests that risks and risk events are signals that are intensified or attenuated by amplification stations. Some seemingly minor risks or risk events often produce extraordinary public concerns or vice versa. This effect might be accompanied or caused by group polarization (Sunstein, 2002). In this light, it seems reasonable to assume that different groups of people (such as experts, base station opponents, or laypeople) hold different affective reactions to mobile communication. By drawing on the these theories, the present work is dedicated to exploring the role of affect in the perception of mobile phones and their base stations in more detail.

The first part of this work concentrates on different operationalizations of affect in the context of risk perception. More precisely, Chapter II presents the results of a single category variant of the IAT designed to measure global positive or negative reactions to mobile communication. These results are directly linked to findings from the psychometric paradigm. The specific affect-laden words and images that people have in mind when they think of mobile phone base stations will be investigated in Chapter III. The next chapter (Chapter IV) addresses specific emotions: fear and anger. How these specific emotions emerge will be analyzed and discussed, and how they influence risk/benefit judgments and acceptance of mobile phone base stations.

Second, this work also explores how knowledge influence base station decisions. In Chapter V, participants are asked to find an appropriate site for a base station in a hypothetical village. Different attributes of the base station (for instance, the location) are considered during this task. The study addresses the question what kind of base station attributes are deemed most important by laypeople, and whether these preferences depend on variables such as trust, health beliefs, and knowledge. Little is known about such public preferences, although public authorities and risk communication facilitators would profit from these insights. Finally, in Chapter VI, the influence of knowledge on siting decisions (as well as on health concerns and explicitly stated affect) will be investigated experimentally. Table 1.4. gives an overview of the respective chapters and the central research questions.

Table 1.4. Overview of the Research Questions and Methods

	Chapters and Research Questions	Method
(I.)	***(Introduction)***	
II.	**Implicit associations to mobile phones, mobile phone base stations, and other hazards** • Are implicit associations connected to explicit affect? • Do experts, opponents, and laypeople differ in their implicit associations? • Is the dread dimension of the psychometric paradigm related to implicit associations?	Single Category Implicit Association Test
III.	**Free associations to mobile phone base stations** • Do experts, opponents, and laypeople differ in their free associations? • Regarding the general population, what are the first words or images that come to people's minds? • Do people with a high risk perception differ from those with a low risk perception?	Free Associations Technique
IV.	**The influence of fear and anger on risk judgments and acceptance** • How do specific emotions influence risk and benefit perceptions, and the acceptance of base stations? • What are the antecedents of fear and anger in a risk context?	Structural Equation Modeling
V.	**Public preferences for mobile phone base station sites** • Which aspects of base station sites does the public regard as most important? • Are there specific segments of respondents who differ in their preferences? • Can these segments be characterized by other important variables such as trust and knowledge?	Conjoint Measurement
VI.	**Experimental manipulation of knowledge about mobile communication** • Does the provision of knowledge lead to a change in siting decisions, public concerns, and explicitly stated affect?	Experiment
(VII.)	***(General Discussion)***	

Chapter II: Examining the Relationship between Affect and Implicit Associations: Implications for Risk Perception

This chapter highlights the importance of affect in shaping attitudes and opinions toward risks. Two studies are presented that used a Single Category Implicit Association Test (SC-IAT) to measure associations evoked by different hazards. Primarily, it was tested whether the SC-IAT corresponds to the theoretical construct of affect in a risk framework. Specifically, it was found that the SC-IATs correlated with other explicit measures that claim to measure affect, as well as with a measure of trust, but not with a measure that captures a different construct. Furthermore, it was revealed that effects of a Mobile Phone SC-IAT and a Base Station SC-IATs were significantly different between matched samples of experts, base station opponents, and laypeople.

The second study examined whether hazards that vary along the dread dimension of the psychometric paradigm also differ in the affect they evoke. The results of the SC-IAT indicated that a high-dread hazard (nuclear power) elicits negative associations. Moreover, the high-dread hazard evoked more negative associations than a medium-dread hazard (hydroelectric power). In contrast, a non-dread hazard (home appliances) led to positive associations. The results of the SC-IAT support the assumption that affect is strongly linked to the degree to which a hazard evokes feelings of dread. The findings further suggest that implicit measures may provide valuable insight into people's risk perception above and beyond explicit measures.

Chapter III: Mobile Communication in the Public Mind: Insights from Free Associations to Mobile Phone Base Stations

The prior chapter demonstrated that experts, opponents, and laypeople differ in their automatic affective reactions to mobile communication. The SC-IAT, however, is designed to investigate global spontaneous evaluations and provides no insights into the specific words or images that experts or laypeople have in mind when they evaluate mobile communication. Such images might be best explored using a free association method, which captures the first words or images that come to a person's mind in response to a certain cue. In a first study, considerable differences in free associations to *mobile phone base stations* between experts and base station opponents were found. The prevalence of free associations in a large random sample from the general population was explored via correspondence analysis in a second study. The results of these studies were in line with the affect heuristic that guides risk and benefit assessments.

Chapter IV: Fear and Anger: An Emotion-Specific Approach to Risk Judgments

Chapter IV examines how specific integral emotions influence decisions and judgments. More precisely, the study investigated how fear and anger determine risk and benefit perceptions and the acceptance of a technology. Using structural equation modeling, the study found that risk perception of mobile phone base stations was more strongly influenced by fear than by anger. On the other hand, benefit perceptions and the acceptance of mobile phone base stations were primarily determined by anger. In addition, controllability and fairness emerged as important cognitive appraisals for these two emotions. In sum, our findings highlight how specific emotions, rather than global affect, shape decisions in a risk context. Furthermore, the study gives insights into how emotions toward a hazard develop and, thus, how they could be modified.

Chapter V: Conjoint Measurement of Base Station Siting Preferences

This chapter explores how affective (i.e., trust) and other variables such as health beliefs and knowledge influence base station siting decisions. A random sample of 503 persons from the German-speaking part of Switzerland was interviewed face-to-face in their homes. Conjoint analysis was used to evaluate participants' preferences for various attributes of base stations (appearance, location, building, decision process). The results show that location plays the most important role in participants' acceptance of base stations. The findings also indicate that most people would prefer a covered or camouflaged base station to a freely visible one. A cluster analysis distinguished several segments, showing that base station siting preferences were not homogeneous. These segments differed in risk and benefit perceptions, and in knowledge, health beliefs, and trust.

Chapter VI: The Impact of Specific Information Provision on Base Station Siting Preferences

When it comes to the new siting of a mobile communication base station in one's neighborhood, some people react with rejection because they fear health consequences from the emitted high-frequency radiation. Most people would prefer to site base stations outside residential areas, but from a public health perspective, this may result in even more radiation for the phoning population. Therefore, authorities are interested in improving the current base station siting processes. The question arises whether specific knowledge enhancement would influence base station siting preferences or whether affective or emotional components (due to the scientific uncertainties involved) would overrule the influence of such attempts. To answer this question, an experimental study with a convenience sample of Swiss citizens (N = 228) was conducted. Participants were confronted with one of three texts: a neutral text (control group), an information booklet about mobile communication and an emotionally charged newspaper article that reported a conflict about the siting of a new base station. After reading the text, participants filled out a questionnaire about their perception of mobile communication and their base station siting preferences. Reading the information booklet increased participants' knowledge and led to perceptual changes of base stations and mobile phones. Importantly, participants reading the booklet were able to transfer their knowledge to a base station siting task and found locations that would emit less radiation for the phoning population. Implications and limitations of these results are discussed.

Chapter VII: General Discussion

Finally, the general discussion summarizes and integrates the main findings of this work. Furthermore, methodological issues and limitations will be discussed, and implications for research and practice will be derived.

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Chapter II

Examining the Relationship between Affect and Implicit Associations: Implications for Risk Perception

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Manuscript accepted for publication as: Dohle, S., Keller, C., & Siegrist, M. (2010). Examining the relationship between affect and implicit associations: Implications for risk perception. *Risk Analysis, 30(7), 1116–1128.*

Abstract

It has been suggested that affect may play an important role in risk perception. Slovic *et al.* argued that people make use of the “affect heuristic” when assessing risks because it is easier and more efficient to rely on spontaneous affective reactions than to analyze all available information. In the present studies, a Single Category Implicit Association Test (SC-IAT) to measure associations evoked by different hazards was employed. In the first study, we tested the extent to which the SC-IAT corresponds to the theoretical construct of affect in a risk framework. Specifically, we found that the SC-IAT correlates with other explicit measures that claim to measure affect, as well as with a measure of trust, but not with a measure that captures a different construct (subjective knowledge). In the second study, we addressed the question of whether hazards that vary along the dread dimension of the psychometric paradigm also differ in the affect they evoke. The results of the SC-IAT indicated that a high-dread hazard (nuclear power) elicits negative associations. Moreover, the high-dread hazard evoked more negative associations than a medium-dread hazard (hydroelectric power). In contrast, a non-dread hazard (home appliances) led to positive associations. The results of our study highlight the importance of affect in shaping attitudes and opinions toward risks. The results further suggest that implicit measures may provide valuable insight into people's risk perception above and beyond explicit measures.

1. Introduction

The psychometric paradigm has been the most influential approach to the examination of risk perception and has been used in numerous studies (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, 1987). In these studies, participants usually respond to different rating scales for a set of hazards. Principal component analysis is then used to identify the factors that determine the perception of these hazards, typically revealing two components. One component, labeled “unknown risk,” loads highly on scales of perceived newness, perceived scientific knowledge, and delay of effect. The other component loads on such scales as perceived lack of control, dread potential, and fatal consequences. This component is labeled “dread risk.”

It is important to bear in mind, however, that these labels are interpretations from the factor loadings. More than one interpretation can be made of the same data, and interpretations of factors should be validated against external criteria. The rating scales that constitute the dread risk component are heterogeneous; not only dread potential but also cognitive rating scales correlated highly with the dread risk dimension. More recently, it has been suggested that the dread risk component is closely linked to affect (Slovic, Finucane, Peters, & MacGregor, 2002; Visschers & Siegrist, 2008). It is still unclear, however, whether this interpretation bears up under empirical investigation. One reason that this assumption has not yet been tested might be that affect is a construct that is not easy to capture. In the present research, we applied a Single Category Implicit Association Test (SC-IAT, Karpinski & Steinman, 2006), which might be an appropriate proxy for affect in risk perception. The SC-IAT assesses people’s associations via response latencies. Because little is known about how the SC-IAT relates to other affect measures in risk research, the first aim of our research was to explore whether the SC-IAT offers a sufficient degree of validity and reliability in a risk context. In the second step, we wanted to examine the relationship between affect and the “dread risk” dimension in more detail.

1.1. Affect in Risk Perception

Affect is an important determinant of perception and behavior. Slovic et al. (2002) describe affect as “the specific quality of ‘goodness’ or ‘badness’ (1) experienced as a feeling state (with or without consciousness) (2) demarcating a positive or negative quality of a stimulus. Affective responses occur rapidly and automatically.” In the field of risk research, reliance on affective feelings was termed “the affect heuristic” (Finucane, Alhakami, Slovic,

& Johnson, 2000; Slovic et al., 2002; Slovic, Finucane, Peters, & MacGregor, 2004). It has been argued that people use the affect heuristic because relying on spontaneous affective reactions is easier and more efficient than analyzing all available information. In a similar vein, Loewenstein et al. (Loewenstein, Weber, Hsee, & Welch, 2001) introduced the “risk as feeling” model, which highlights the role of affect experienced immediately during decision making. The idea that affect plays an important role in decision making and risk perception is also central in several dual-process models (Epstein, 1994; Gawronski & Bodenhausen, 2007a; Slovic et al., 2004). Slovic et al. (2004) assumed that there are two modes of thinking, the experiential system and the analytic system. The analytic system, on the one hand, is considered to be slow and effortful, and requires conscious control. This system relies on probabilities, logical reasoning, and evidence. The experiential system, on the other hand, is intuitive, fast, mostly automatic, and not very accessible to conscious awareness. This system relies on images, metaphors, and narratives, and is assumed to be associated with the experience of affect (Gawronski & Bodenhausen, 2007a). Especially for laypeople, decisions about risks are often too complex to allow consideration of all pros and cons; it seems reasonable to assume that laypeople may use the experiential system to evaluate risks. Time pressure and limited cognitive resources may also lead to a pronounced reliance on the experiential system and, thus, on affect (e.g., Vorhold et al., 2007).

1.2. Implicit Measures

In the field of risk research, affect is typically measured via self-reports. In most studies, participants are asked to indicate on a scale whether they evaluate a certain hazard as positive or negative, good or bad (see, for example Alhakami & Slovic, 1994). This conceptualization of affect strongly resembles what social psychologists consider to be an attitude: the evaluation of the “goodness” or “badness” of something (Spence & Townsend, 2008).

In a social psychology framework, a distinction is further made between explicit and implicit attitudes. Explicit attitudes (such as affect in risk research) are usually equated with deliberative, self-reported evaluations. They rely on the assumption that people generally have access to the strength of their evaluative associations. Accordingly, people know if they have positive or negative associations with an object. However, it has been repeatedly shown that people often have difficulty in identifying their own mental processes, because these can lie beyond one’s introspective capability (Nisbett & Wilson, 1977; Wilson & Brekke, 1994).

In addition, some questions may evoke social desirability concerns, e.g., when questions enter displeasing or embarrassing domains. These concerns may lead participants to alter their responses when explicitly asked.

Implicit measures of attitudes try to overcome these shortcomings by assessing associations indirectly. The idea behind implicit measures is that they capture associations (e.g., *nuclear power* + *bad*) that are stored in memory without requiring introspection on the part of the subject (Perkins, Forehad, Greenwald, & Maison, 2008). One of the most prominent implicit measures is the Implicit Association Test (IAT), which was introduced by Greenwald and colleagues (Greenwald, McGhee, & Schwartz, 1998). The IAT measures the relative association strength between concepts by observing response latencies in a computerized categorization task (Greenwald, Poehlman, Uhlmann, & Banaji, 2009). Participants conducting an IAT are instructed to sort stimuli that appear on a computer screen. For example, in one of the IATs used by Greenwald et al. (1998), participants first categorized names of insects and names of flowers using two keys. The keys were named after the target categories (*flowers* vs. *insect*). In a subsequent block, another pair of concepts (*pleasant* vs. *unpleasant*) was contrasted using the same two keys. In the following two critical parts of the IAT, the first and second blocks were combined. One time, one response key stood for *flower* + *pleasant* and the other for *insect* + *unpleasant*. Another time, the keys represented the combination *flower* + *unpleasant* and *insect* + *pleasant*. The IAT effect indicates which of the two combined tasks can be conducted faster by participants. In the example outlined above, participants responded faster to the combination *flower* + *pleasant* and *insect* + *unpleasant* than when *flower* was paired with *unpleasant* and *insect* with *pleasant*. The rationale underlying the IAT is that the categorization task is much easier when the two combined concepts are strongly associated in memory.

Since the test’s introduction, the IAT has been used in a diverse array of disciplines and studies (for an overview see Lane, Banaji, Nosek, & Greenwald, 2007). The IAT is a flexible as well as a reliable instrument (Friese, Wänke, & Plessner, 2006), which may explain the IAT’s broad popularity among researchers. Nonetheless, the IAT has also been criticized for methodological and theoretical limitations (for an overview, see Gawronski, 2009).

Interestingly, the IAT has been shown to correlate more strongly with explicit (self-report) measures when these explicit measures have an affective focus, such as feeling thermometers, as compared to measures with a cognitive focus, like trait ratings (Hofmann, Gschwendner, & Schmitt, 2005). In fact, some researchers have argued that the IAT provides a proxy for immediate affective reactions to a given object (Gawronski & Bodenhausen, 2007a). However, empirical evidence about the link between implicit measures and affect remains sparse or ambiguous (Spence & Townsend, 2008). Phelps and colleagues (2000), for example, found that the relative strength of amygdala activation was correlated with the race IAT effect but not with explicit race attitudes. The amygdala, a brain region in the medial temporal lobes, has been associated with the processing and recollection of emotional stimuli (e.g., Zald, 2003). However, amygdala activation has also been linked with evaluations more generally. Other studies using fMRI (Chee, Sriram, Soon, & Lee, 2000; Richeson et al., 2003) showed that IAT performance was also related to activation in the dorsolateral prefrontal cortex, a region that reflects deliberative inhibition. These results suggest that the IAT effect is not process pure but triggered by multiple processes (Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005; Gawronski & Bodenhausen, 2007b). In sum, one might argue that the connection of implicit measures and affect is best described such that affect appears to be a central *component* of implicit evaluative associations, which may be more or less salient within different topics (Giner-Sorolla, 2004).

Only a few studies have used implicit measures to assess evaluative associations of different hazards (Siegrist, Keller, & Cousin, 2006; Spence & Townsend, 2007; Visschers, Meertens, Passchier, & de Vries, 2007). For example, Siegrist et al. (2006) employed a traditional IAT (i.e., using the IAT procedure described above) and contrasted nuclear power with hydroelectric power. They showed that the IAT was capable of revealing negative associations regarding nuclear power that were not detected by explicit measures. These results suggest that implicit measures may give important insight into the perception of risks, and into the role of affect in risk perception.

These studies often assume that implicit measures are a good proxy for measuring affect, but only little is known about the validity of implicit measures in risk perception. The few existing studies that have explored this issue come from clinical psychology, exploring pathological risk perception such as spider phobia or alcohol abuse (Teachman & Woody, 2003; Wiers, van Woerden, Smulders, & de Jong, 2002). Thus, the first aim of our studies was to examine the validity of the IAT in an environmental risk context. We were interested in whether and how the IAT is related to other measures that measure affect explicitly, and to measures that capture other, unrelated constructs.

In addition, the study was designed to test a newly developed variant of the IAT that might be more appropriate in measuring implicit association regarding risks. One major shortcoming of studies using the traditional IAT is that it is a relative measure, i.e., it is not possible to make conclusions about evaluative associations with a single hazard. For instance, in an IAT that contrasts evaluative associations of hydroelectric power with nuclear power, a high negative score could indicate that participants have either many *hydroelectric power + pleasant* associations or many *nuclear power + unpleasant* associations. Furthermore, if researchers want to investigate the evaluative associations of more than two attitude objects, the number of required IATs would increase rapidly to a great number of pairwise comparisons. To solve the above-mentioned limitations, several non-relative tasks have been suggested. Among those, the Single Category IAT (SC-IAT) stands out among other measures because of its satisfactory psychometric properties (Bluemke & Friese, 2008; Karpinski & Steinman, 2006). It is a modification of the traditional IAT procedure and omits the complementary category. Thus, when naturally opposing categories are unavailable and absolute evaluations are of most interest, the SC-IAT is considered to be the most advantageous implicit measure (Bluemke & Friese, 2008). For this reason, we decided to utilize the SC-IAT in the present studies.

2. Study 1: Assessing the Validity of the SC-IAT in the Field of Risk Perception

The objective of Study 1 was to evaluate the construct validity of the SC-IAT. Construct validity is the extent to which an operationalization measures the construct that the operationalization is supposed to measure (Nunnally & Bernstein, 1994). Empirical indicators for construct validity are convergent and discriminant validity (Campbell & Fiske, 1959). Convergent validity is achieved when different measurements claiming to measure the same construct correlate positively. Discriminant validity is achieved when different measurements of different construct diverge (i.e., do not correlate or correlate weakly). Thus, we expected that the SC-IAT correlates with other explicit measures that claim to measure affect. In a study by Peters and Slovic (2007), where various affective self-reports were tested, the authors recommended that “further research with self-reports of the affective component include the holistic, unipolar, discrete emotion (HUE) evaluative measures […] in combination with a holistic bipolar valenced evaluation measure” (p. 300). On these grounds, we tested the convergent validity of the SC-IAT with the two explicit measures mentioned above. Furthermore, the SC-IAT should also be related to trust, because trust is assumed to have affective components as well (Visschers & Siegrist, 2008). On the other hand, because affect is considered to be part of the experiential system, the SC-IAT should not correlate with a construct that is based in the analytic system (i.e., subjective knowledge about the hazard).

To test our predictions, we investigated two technologies, mobile phones and mobile phone base stations. We recruited participants who were experts about electromagnetic fields (EMF) and matched the experts with people who were opposed to mobile phone base stations and with people from the general population. This sample was chosen because we expected that affect toward the technology would vary strongly in this sample, providing an ideal precondition for comparing correlations. Furthermore, a difference in implicit evaluations between the three groups would further corroborate the criterion-related validity of the SC-IAT.

2.1. Method

2.1.1. Participants

A total of 63 persons from the German-speaking part of Switzerland were included. One third were experts on mobile phone communication (n = 21), one third were opponents of mobile phone communication (n = 21), and the remaining third were selected from the general population (n = 21). The matching criteria were gender, age (within a five-year band), and self-reported education (five levels: primary school, lower secondary school, upper secondary vocational school, upper secondary university-preparation school, and college or university).

We selected experts with different backgrounds and viewpoints on the topic. Six of the experts indicated that they were working in the field of basic EMF research, seven in the field of applied EMF research, four in general risk research, five for federal authorities, seven for a cantonal or municipal authority, and one for a consumer protection board (multiple answers possible). On average, the experts stated that they had been engaged in the topic of non-ionizing radiation for 9.86 years (SD= 4.43), and all but one stated that they regularly read scientific publications on the topic.

Each expert was matched with a base station opponent and a person from the general public. Opponents were recruited via Internet platforms of citizens' action committees, and within the committees, by word of mouth. Participants from the general public were randomly drawn from the electronic telephone directory. Similar to the opponents, the general public participants were first called and asked about their age and educational background to find adequate matches. If the criteria were fulfilled, appointments were made at the participant's home or office.

2.1.2. Measures and Procedure

In the first part of the study, participants were asked to associate freely about the terms "mobile phone" and "mobile phone base station." The results of this task are not central for the present purpose and are not reported here. After the association task, two SC-IATs were administered on a portable computer (Lenovo 1.8 GHz dual core ThinkPad) using Inquisit software (www.millisecond.com). Each of the SC-IATs took approximately 5–10 minutes. Afterwards, participants completed a questionnaire designed to assess their explicit affect, as well as trust and subjective knowledge. These questions appeared on the computer screen, and participants responded via the computer keyboard. Because several studies revealed that the order of measures does not influence the relationship of implicit and explicit measures (Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005; Nosek, 2005; Nosek, Greenwald, & Banaji, 2005), the order of implicit and explicit measures remained constant. During the whole study, care was taken to ensure that no distraction from outside (e.g., phone calls) could occur to disrupt the procedure.

SC-IAT. The two SC-IATs differed with respect to their target category, i.e., "mobile phone" and "mobile phone base station." Each SC-IAT consisted of two blocks, while each block included 24 practice trials and 72 test trials. In the first block, participants categorized target stimuli and positive stimuli on the right key ("I") and negative stimuli on the left key ("E"). In the second block, the assignment of the target category was changed so that target stimuli and negative stimuli shared the same response key ("E"). Furthermore, half of the participants conducted the study in the sequence described above, while for the other half of participants the sequence of blocks was reversed to prevent position effects.

The words related to the positive and negative categories were taken from Siegrist *et al.*,[30] although two words of the negative category were replaced with novel stimuli. The four words relating to the positive category were enjoyable, likable, pleasant, and good. The four words related to the negative category were atrocious, bad, displeasing, and repulsive.

Because of difficulties in finding an appropriate set of words that were adequate characterizations of the target category, we also included pictures that represented the target category. For each target category, three words and three pictures served as stimuli. The target black-and-white pictures were all standardized to 240 x 320 pixels (72ppi), resulting in a size of 6 x 8 cm on the computer screen. Target stimuli as well as coupled and uncoupled evaluative stimuli were presented in a 7:7:10 ratio to ensure that the proportion of left-hand and right-hand responses was approximately equal. An intertrial stimulus interval of 500 ms was used.

All participants received the same fixed random order of stimuli. To urge participants to respond rapidly to the stimuli, a reminder ("Please respond more quickly!") appeared on the screen if participants did not respond within 3000 ms. In addition, a green *O* and a red *X* for 150 ms followed correct and incorrect responses, respectively. The sequence of the two SC-IATs was alternated.

Self-reports. Participants then answered different items that were designed to measure the participants' explicit affect toward mobile phones and mobile phone base stations. Two other scales assessed trust in mobile communication authorities and subjective knowledge about mobile communication.

For both technologies, participants first filled in the HUE scale, which included holistic unipolar discrete emotion items. The scale consisted of five positive terms (happy, friendly, enthusiastic, love, and excited) as well as five negative terms (upset, angry, annoyed, disgust, and afraid). Participants responded on a 4-point scale ranging from 1 ("does not apply/describe") to 4 ("completely describes"). For each HUE scale, a mean score of all items was calculated. The reliability of these scales was checked by calculating Cronbach's alpha. The scales for both technologies were reliable (base stations $\alpha = .66$; mobile phones $\alpha = .75$).

Next, respondents were asked to describe their feelings toward the two technologies (holistic bipolar valenced evaluation measure). Respondents used a 6-point rating scale ranging from -3 ("negative") to +3 ("positive") to answer these questions.

To examine trust in mobile communication authorities, participants were asked to rate how much they trust several authorities and their specific sphere of authority. Judgments were made about (a) providers (technical aspects), (b) providers (health aspects), (c) federal authorities (legal framework), (d) federal authorities (health care), (e) cantonal authorities (approval procedure), (f) research groups at universities (research), and (g) consumer protection boards (consumer safety). In answering these questions, respondents used a 6-point rating scale ranging from 1 ("no trust") to 6 ("complete trust"). The final trust measure consisted of an average of its individual items. Reliability analysis revealed a high Cronbach's alpha ($\alpha = .82$).

Finally, participants were asked to judge their subjective knowledge about mobile communication. More specifically, they were asked to judge their subjective knowledge about (a) the risks, (b) the technical aspects, and (c) the legal aspects of mobile communication. Participants answered these questions on a 6-point-scale ranging from 1 (“not informed at all”) and 6 (“very well informed”). The three items were averaged; reliability (Cronbach’s alpha) of the subjective knowledge scale was $\alpha = .84$.

2.2. Results

2.2.1. Data Processing

For the two SC-IATs, the response latencies (in milliseconds) and error rates for each trial were recorded by the computer. The scoring algorithm developed by Karpinski and Steinman (Karpinski & Steinman, 2006), modeled on the D-Score algorithm for IAT data (Greenwald, Nosek, & Banaji, 2003), was used for the data processing. According to this, participants with an error rate greater than 20% in one of the two SC-IATs should be excluded from further analyses. One participant from the general population and one participant from the base station opponents were above this criterion and were excluded from the SC-IAT analysis.

The first 24 trials of each block were not included in computations because those trials served as practice trials. Trials with latencies of less than 350 ms or longer than 3000 ms were eliminated. Response errors were replaced with the block mean plus 400 ms. The mean response times for the block combining stimuli from the target and the positive category (Block 1) were subtracted from the block combining the target and the negative category (Block 2). Each difference score was divided by the standard deviation of the correct responses within both blocks of the SC-IAT, which was used as the SC-IAT effect. Thus, a positive score indicates that the target is more related to positive concepts, and a negative value that the target is associated with negative concepts. Finally, the EXAMINE procedure of SPSS was used to detect outliers or extreme values (values more than 1.5 or 3 interquartile ranges, respectively). One subject who was an outlier for the Mobile Phone SC-IAT effect was identified and discarded from further analyses concerning implicit associations.

2.2.2. SC-IAT

First, we calculated the reliability of the two SC-IATs. Each SC-IAT (only test trials) was divided into thirds, and for each third, a separate SC-IAT score was computed. Because separating the task into thirds underestimates the reliability of the entire measure, the Spearman-Brown correction was applied. The reliability score for the Base Station SC-IAT was somewhat higher (r = .81) than the score for the Mobile Phone SC-IAT (r = .72).

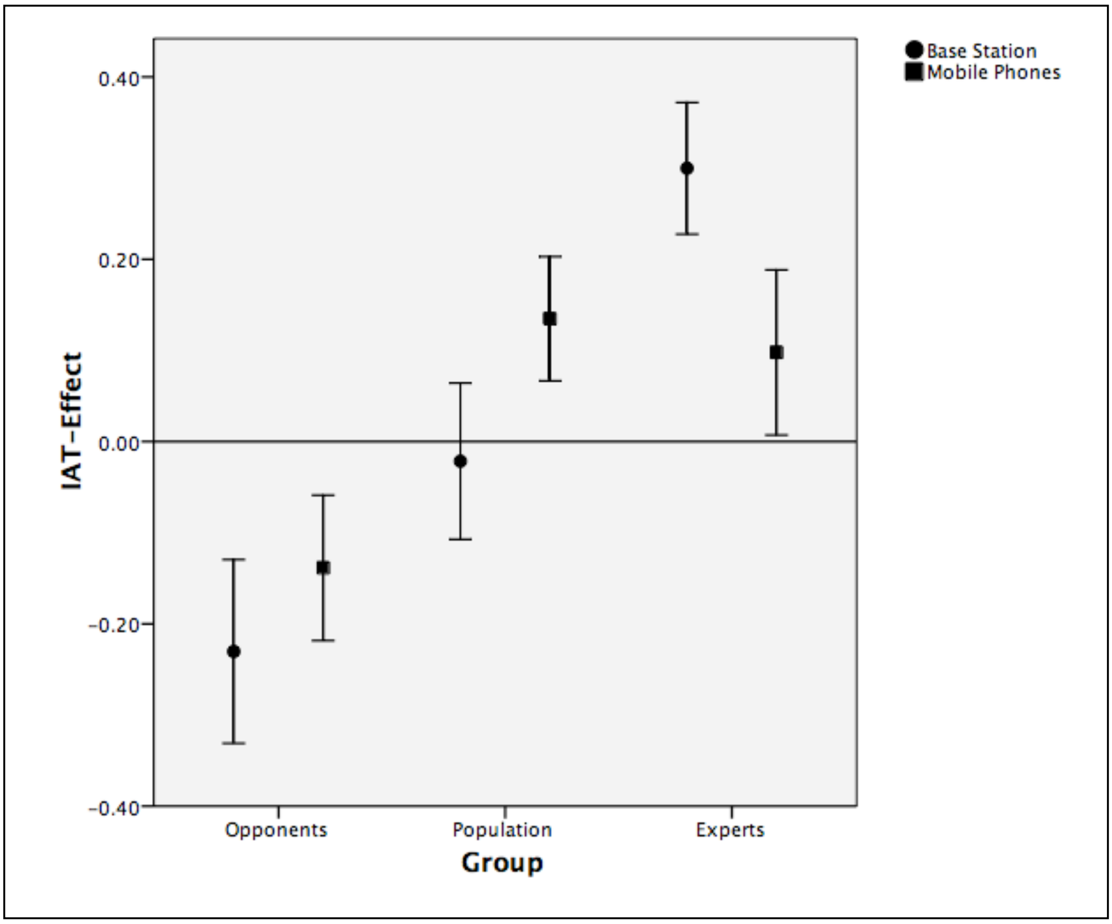

Figure 2.1. IAT-Effects (mobile phone base stations and mobile phones) for the matched groups (Study 1). Error bars indicate the standard errors of the means.

A closer look at the Base Station SC-IAT (see Figure 2.1.) results reveals that the opponent group held negative implicit associations toward base stations (M = -0.21, SD = 0.44). The Base Station SC-IAT effect for those participants was significantly more negative than zero, $t(19)$ = 2.19, p = .041. In contrast, base stations evoked positive implicit associations in the expert group (M = 0.30, SD = 0.33); the Base Station SC-IAT effect in this group was significantly more positive than zero, $t(20) = 4.15$, $p < .001$. For participants from the general population, the Base Station SC-IAT effect was neither positive nor negative ($M = 0.03$, $SD = .43$), $p > .7$. A one-way ANOVA showed that there were differences in the Base Station SC-IAT effect between the three groups, $F(2, 58) = 8.44$, $p = .001$. Post hoc tests (Tukey HSD) were used to analyze this difference in more detail. They revealed that base station opponents showed more negative implicit associations than the expert group, $p < .001$. In addition, there was a trend that participants from the general population differed from participants from the expert sample. This trend was not significant, however; $p = .085$.

For base station opponents, mobile phones also evoked negative implicit associations, ($M = -0.15$, $SD = 0.34$); the Mobile Phone SC-IAT effect for opponents reached marginal significance, $t(19) = 1.92$, $p = .070$. The Mobile Phone SC-IAT effect was neutral for the expert group ($M = 0.10$, $SD = 0.42$); and did not differ significantly from zero, $p > .29$. In contrast, participants from the general population showed positive implicit associations towards mobile phones ($M = 0.14$, $SD = .30$), the Mobile Phone SC-IAT effect was marginally positive, $t(18) = 1.98$, $p = .063$. A one-way ANOVA revealed that there were differences in the Mobile Phone SC-IAT effect between the three groups, $F(2, 57) = 3.64$, $p = .033$. Base station opponents held more negative implicit associations with mobile phones than did the group from the general population, $p = .044$. There was also a non-significant trend that opponents showed more negative implicit associations than the expert sample, $p = .082$ (Tukey HSD).

2.2.3. Correlations

Table 2.1. shows the correlation matrix for the two SC-IATs and the explicit affect. For both technologies, the convergent validity of the SC-IATs was indicated by a high correlation of the SC-IAT with the HUE scale and with the holistic bipolar valenced evaluation measure. Moreover, the convergent validity was confirmed by the high correlation of the SC-IATs with the measure of trust in mobile communication authorities. In contrast, the SC-IATs did not correlate with subjective knowledge, indicating the discriminant validity of the SC-IAT. Furthermore, we found that the HUE scale and the holistic bipolar valenced evaluation measure (both designed to measure affect explicitly) correlated positively for both technologies.

Table 2.1. Correlations (Study 1)

Measures	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. SC-IAT (BS)	1							
2. Holistic bipolar valenced evaluation measure (BS)	.477**	1						
3.HUE scale (BS)	.391**	.403**	1					
4. SC-IAT (MP)	.242	.333**	.409**	1				
5. Holistic bipolar valenced evaluation measure (MP)	.244	.465**	.253*	.267*	1			
6.HUE scale (MP)	.379**	.405**	.290*	.307*	.596**	1		
7. Trust	.516**	.691**	.359**	.285*	.432**	.621**	1	
8. Subjective knowledge	.148	.321*	.157	-.032	.105	-.111	.026	1

Note. SC-IAT = Single Category Implicit Association Test; BS = Base Station; MP = Mobile Phones; *p<0.05, **p<0.01

2.3. Discussion

Study 1 demonstrates that both SC-IATs had sufficient reliability. Both reliability scores were in the same range as found in other studies (Karpinski & Steinman, 2006). Moreover, the study results suggest that the SC-IAT is related to explicit affective measures of the same technology, and to trust. Again, this was true for both the Mobile Phone SC-IAT and the Base Station SC-IAT. It is noteworthy that the correlations of the SC-IATs with explicit measures in our study were quite high compared with other studies. Two recent meta-analyses exploring the relationship between the traditional IAT and self-reports find an average correlation of .24 (Hofmann, Gawronski et al., 2005) and .36 (Nosek, 2005), respectively. In the present study, all correlations of the SC-IAT with the two explicit affect measures or trust exceed the average correlations of Hofmann et al.’s (2005) meta-analysis, and most strikingly, the correlation of the Base Station SC-IAT with trust is the highest of all. None of the SC-IATs correlated with subjective knowledge, supporting the discriminant validity of the SC-IAT. In addition, the finding that the two SC-IATs were significantly different between the three groups corroborated the criterion-related validity. Taking the results together, it is tenable that the SC-IAT measures affective responses in a risk context.

3. Study 2: Affect and Feelings of Dread

To explore the relationship between the dread risk factor and affect more precisely, a second study was conducted. The main purpose of this second study was to test the assumption that hazards that vary along the dread dimension of the psychometric paradigm would also differ in the affect they evoke. In Study 2, implicit associations regarding three hazards were examined, i.e., nuclear power, hydroelectric power, and home appliances. These three hazards can be located along the "dread risk" dimension of the psychometric paradigm.[1] Nuclear power is perceived as an extremely high-dread hazard, hydroelectric power as medium dread, and home appliances as non-dread (Siegrist, Keller, & Kiers, 2005).[2] It was assumed that the three hazards would differ in their implicit associations (measured via three SC-IATs). We hypothesized that nuclear power would evoke more negative associations than hydroelectric power and that home appliances would evoke more positive associations than hydroelectric power. In addition, we also assessed explicit affect using the holistic bipolar valenced evaluation measure, which was also used in Study 1. This time, we used only one measure for the explicit affect, since the results of Study 1 indicated that the HUE scale and the holistic bipolar valenced evaluation measure are correlated. According to Alhakami and Slovic's (1994) results, affect should also be connected to the perceived risks and benefits of the hazards (see also Finucane et al., 2000; Slovic et al., 2004; White, Eiser, Harris, & Pahl, 2007).

[1] In our study, we selected only these three hazards, since conducting an SC-IAT demands time and attention. By contrast, studies using the psychometric paradigm typically examine a large set of hazards. For the present study, we chose three hazards from the psychometric paradigm that varied on the dread dimension, and that could be easily and unmistakably pictured in the SC-IAT as well.

[2] Siegrist et al. (2005) conducted a mail survey to examine individual differences in risk perception. The researchers reported the results of a three-way principal component analysis. Details of a two-way principal component analysis, including a "cognitive map" that depicts a range of hazards in a two-dimensional space, are available on request from the authors.

3.1. Method

3.1.1. Participants

Eighty-three undergraduates from the University of Zurich participated in the study (44 males, 39 females). Psychology students received credit for participation. The majority were studying psychology (66%) or other social sciences (18%). The remaining participants were studying law (5%) or natural sciences (4%) or did not specify their major (7%). The participants' mean age was 25.44 years (*SD* = 6.43).

3.1.2. Measures and Procedure

The study described here was preceded by an unrelated study that examined decisions about nutrition, which took approximately 30 minutes. In our study, participants were tested in groups of three or fewer. Each person was seated in front of one of three portable computers (Lenovo 1.8 GHz dual core ThinkPad using Inquisit software), which were placed outside the range of vision of the other participants. During the first part of our study, participants completed three SC-IATs at the computer. In the second part of our study, participants answered some explicit questions that appeared on the computer screen. These questions assessed the explicit affect toward the three hazards, as well as their perceived risk and benefits. Participants were asked to remain silent during the study and were requested to indicate questions about the procedure by raising their hands.

Implicit Measure. The design of the SC-IAT as described in Study 1 was used. Three hazards served as target category, i.e., nuclear power, hydroelectric power, and home appliances. The sequence of the three SC-IATs was controlled via a Latin square so that each SC-IAT was conducted equally often in each position.

Self-reports. After taking the SC-IATs, participants answered three questions assessing the participants' explicit affect toward nuclear power, hydroelectric power, and home appliances; judgments were to be made about the participants' feelings toward the three hazards (holistic bipolar valenced evaluation measure), using a 6-point rating scale ranging from -3 ("negative") to +3 ("positive"). To assess the perceived risk and benefit of each hazard, participants were asked to judge how risky (beneficial) they considered the hazard to be for Swiss society as a whole. They used a 6-point rating scale ranging from 1 ("small") to

6 (“large”) to answer these questions. Finally, participants were asked for some personal data including age, gender, and course of study.

3.2. Results

3.2.1. SC-IATs

Data processing of the SC-IATs was the same for Study 2 as for Study 1. No participant had an error rate greater than 20% in any of the three SC-IATs. Furthermore, the EXAMINE procedure of SPSS was again used to detect outliers or extreme values. It revealed that two subjects showed an outlying SC-IAT effect; they were discarded from further analyses regarding implicit associations.

As in Study 1, we calculated the reliability for each of the three SC-IATs (all scores were Spearman-Brown corrected). The reliability score of the Home Appliances SC-IAT was the highest ($r = .76$). The other reliability scores were lower (Nuclear Power SC-IAT: $r = .55$; Hydroelectric Power SC-IAT: $r = .54$). A repeated-measures ANOVA was used to evaluate the effects of the three SC-IATs. Results show that the examined hazards were perceived differently, $F(2, 160) = 13.65$, $p < .001$. The pattern of means (see Table 2.2.) shows that nuclear power evoked more negative associations than hydroelectric power, and hydroelectric power evoked fewer positive associations than home appliances. There was a clear linear trend for the three SC-IATs, $F(1, 80) = 19.51$, $p < .001$. To test the differences between the SC-IATS, planned comparisons were conducted. We found that the effect of the Nuclear Power SC-IAT was significantly more negative than that of the Hydroelectric Power SC-IAT, $t(81) = 4.68$, $p < .001$. However, the difference between the SC-IAT with the target category “hydroelectric power” and the SC-IAT with the target category “home appliances” was not statistically significant, $t(81) = 0.92$, $p = .36$. Furthermore, it was revealed that the effect of the Nuclear Power SC-IAT was significantly more negative than zero, $t(81) = 2.02$, $p = .046$; and the effect of the Home Appliances SC-IAT was significantly more positive than zero, $t(81) = 4.40$, $p < .001$. The effect of the Hydroelectric Power SC-IAT was also significantly more positive than zero, $t(82) = 4.30$, $p < .001$. There were no significant correlations between the SC-IATs, where all $p > .31$.

Table 2.2. Means of the SC-IAT Effect for Nuclear Power, Hydroelectric Power, and Home Appliances with Standard Deviations in Parentheses (Study 2)

Hazard	SC-IAT
Nuclear power	-0.06 (0.29)
Hydroelectric power	0.15 (0.31)
Home appliances	0.19 (0.40)

Note. SC-IAT = Single Category Implicit Association Test

3.2.2. Self-reports

A repeated-measures ANOVA was also used to analyze the explicit affect toward nuclear power, hydroelectric power, and home appliances. Participants were asked to indicate their feelings about the three hazards (holistic bipolar valenced evaluation measure, see Table 2.3.). The repeated-measures ANOVA indicated that the explicit affect toward the three hazards differed significantly from each other, $F(2, 164) = 118.85$, $p < .001$. Planned comparisons showed that participants reported more negative explicit affect toward nuclear power than toward hydroelectric power, $t(82) = 12.80$, $p < .001$. Participants also expressed more negative explicit affect toward home appliances than toward hydroelectric power, $t(82) = 2.86$, $p = .005$, although hydroelectric power is considered to be a medium-dread hazard and home appliances non-dread according to the psychometric studies (Fischhoff et al., 1978; Siegrist et al., 2005; Slovic, 1987).

Participants also assessed the risks and benefits associated with the different hazards. The results of an ANOVA with repeated measures showed that participants evaluated the risk of the three hazards differently, $F(2, 164) = 53.65$, $p < .001$, as well as the benefits, $F(2, 164) = 21.19$, $p < .001$. As the planned comparisons showed, participants perceived greater risks associated with nuclear power than with hydroelectric power, $t(82) = 8.10$, $p < .001$, but the participants did not associate more risk with hydroelectric power than with home appliances, $t(82) = 1.46$, $p = .149$. Participants also judged nuclear power as less beneficial than hydroelectric power, $t(82) = 3.79$, $p < .001$, and hydroelectric power as less beneficial than home appliances, $t(82) = 2.42$, $p = .018$.

Table 2.3. Means (with Standard Deviations in Parentheses) of Explicit Affect, Perceived Benefits and Risks, and Correlations with the Corresponding SC-IAT (Study 2)

Measure	Hazard	M (SD)	Correlation SC-IAT
Explicit Affect	Nuclear Power	-0.93 (1.75)	.308**
	Hydroelectric Power	2.02 (1.12)	.152
	Home Appliances	1.57 (1.11)	.110
Benefits	Nuclear Power	4.37 (1.36)	.206
	Hydroelectric Power	5.05 (0.94)	.003
	Home Appliances	5.39 (0.73)	-.115
Risks	Nuclear Power	4.04 (1.45)	-.226*
	Hydroelectric Power	2.51 (1.28)	-.100
	Home Appliances	2.25 (1.28)	-.108

Note. SC-IAT = Single Category Implicit Association Test
*p<0.05, **p<0.01

3.2.3. Correlations

The Nuclear Power SC-IAT was related to the holistic bipolar valenced evaluation measure of nuclear power (see Table 2.3.); we found a significant correlation with the explicitly stated affect toward nuclear power (r = .31, p = .005, N = 82). There was also a significant negative correlation with perceived risks (r = -.23, p = .04, N = 82) and a marginally significant positive correlation with perceived benefits (r = .21, p = .06, N = 82). The two SC-IATS that measured associations toward hydroelectric power and home appliances were not related to the explicit affect measure, however (all p > .1).

3.3. Discussion

The results of the implicit measure support the assumption that affect is strongly linked to the degree to which a hazard evokes feelings of dread (Slovic et al., 2002). The SC-

IAT effect regarding nuclear power, hydroelectric power, and home appliances was found to increase linearly, like the hazards' levels of dread. Beyond that, our findings indicate that nuclear power (a high-dread hazard) evoked negative implicit associations. Furthermore, nuclear power evoked more negative implicit associations than hydroelectric power (a medium-dread hazard). In contrast, home appliances (a non-dread hazard) evoked positive implicit associations. Surprisingly, the mean effect of the Home Appliances SC-IAT was not significantly different from the Hydroelectric Power SC-IAT effect. Based on the results of Siegrist et al. (2005) that showed that hydroelectric power is perceived as a medium-dread hazard, we expected that hydroelectric power would elicit more negative implicit associations than home appliances.

Participants were also asked about their explicit affect (using a holistic bipolar valenced evaluation measure). As in the SC-IAT, participants stated more negative feelings toward nuclear power than toward hydroelectric power. Contrary to the SC-IAT, participants had more negative feelings toward home appliances than toward hydroelectric power when asked explicitly. These findings indicate that the explicit affect measure was not able to reproduce the hazards' locations along the dread dimension of the psychometric paradigm. The results also suggest that the results of implicit and explicit measures may differ essentially.

We also found that associations with nuclear energy (measured via SC-IAT) are connected to the perceived risks and benefits of nuclear energy. This finding is in line with the assumption that the affect heuristic guides perceptions of risk and benefit (Alhakami & Slovic, 1994; Finucane et al., 2000; Slovic et al., 2004; White et al., 2007). However, the remaining two SC-IATs were not connected to risk and benefits, which might be due to the fact that stronger evaluations are known to show greater implicit-explicit correspondence than weaker ones (Nosek, 2005). Risks and benefits of nuclear power are presumably more discussed and receive more media coverage than hydroelectric power or home appliances, leading to a greater evaluative strength in the case of nuclear power.

4. General Discussion

The present research examined the relationship between implicit measures and affect in risk perception. In both studies, a SC-IAT measuring implicit associations with different technologies was used. The SC-IAT assesses the relative strength between concepts via response times. In contrast to the traditional IAT, the SC-IAT is able to estimate an absolute evaluation of a certain hazard and not only a relative evaluation.

The first study showed that the SC-IAT was a reliable measure of evaluative associations in a risk context. Furthermore, the study revealed that the SC-IAT and explicit measures of affect covaried, which provides evidence for the convergent validity of the SC-IAT. Medium size effects were observed, and the two measures were more strongly related to each other than in other studies.

The results of the implicit measures in Study 2 provide evidence for the hypothesis that the “dread risk” dimension of the psychometric paradigm might be closely related to affect (Slovic et al., 2002). Thus, these findings support the idea that affective reactions to technologies and activities guide decisions and judgments, which is known as the “affect heuristic”. The results of the SC-IAT highlight that people are quick in their affective reactions to technologies, which is in line with the affect heuristic and therefore with the idea that immediate gut feelings inform people about whether a hazard might be safe or whether it would be better to avoid it (Visschers & Siegrist, 2008). The affect heuristic also corresponds with the notion of the “risk as feelings” model that affective visceral reactions (or “anticipatory” emotions, in contrast to “anticipated” emotions, which are expected to be experienced in the future) occur immediately and, thus, give instantaneous informational inputs to decision making (Loewenstein et al., 2001).

In Study 2, participants’ affect toward the three hazards was also assessed explicitly. In contrast to the implicit measure, the hazards’ locations along the dread dimension of the psychometric paradigm were not reproduced using an explicit measure. Although different moderators for the implicit-explicit consistency have been suggested (Hofmann, Gschwendner et al., 2005), we can only speculate on the origin of the differences between explicit and implicit measures in our study. In the SC-IAT, participants are urged to react very quickly, while participants answering explicit questions have time to consider all the pros and cons of a technology. Thus, the conscious evaluation may have altered spontaneous evaluations of the technologies. Following this line of argumentation, one could argue that implicit measures are more suitable for measuring affect than explicit measures, because affect is generally considered to be located in the fast-working experiential system, which is oriented toward immediate action (Slovic et al., 2004). These rapid feelings might be masked when participants are asked about it directly in self-reports. Accordingly, it is tenable that the

SC-IAT would correlate more with explicit measures of affect, risk, and benefit perception when these explicit measures are assessed under time pressure.

Moreover, our studies highlight that experts and laypeople differ in their implicit associations toward mobile phones and mobile phone base stations. The results of our first study suggest that differences in risk perception between laypeople and experts are due to different affective reactions to technologies. Because our groups were matched, the alternative explanation that this result was due to differences in age, gender, or education can be ruled out.

Some limitations of the present research need to be discussed. In Study 2, it would have been interesting to examine more than three hazards, in particular because studies using the psychometric paradigm mostly investigate a whole set of hazards. Because the SC-IAT demands some amount of attention, however, more than three SC-IATs in succession might have led to a loss of concentration and motivation for the task. It is known from other studies that the SC-IAT effect can be less pronounced toward the end of a within-subject session (Bluemke & Friese, 2008). In our research, the reliability of the SC-IATs was smaller in the second study, where we used three SC-IATs in succession, compared to the reliability of the SC-IATs in the first study, where only two SC-IATs needed to be conducted. Therefore, we believe it is important not to overstrain participants with too many SC-IATs in one session. The limited number of (SC-) IATs that can be conducted in one study, as well as the extended time and effort that are needed to apply this measure, is clearly a disadvantage for the IAT in comparison to other, explicit measures. It would therefore be all the more useful to explore the differences between implicit and explicit measures in greater detail. Specifically, such future studies may provide insights into the question of which measurement techniques are superior in their predictive validity concerning risk perception or which are more sensitive concerning experimental manipulations of affect.

In addition, the dread risk component of the psychometric paradigm is calculated using principal component analysis, which uses aggregated individual data (Fischhoff et al., 1978; Slovic, 1987). Therefore, we could not measure the dread risk component directly, e.g., by asking participants about the terribleness of a hazard. Instead, the hazards location on the dread dimension was inferred from a study conducted by Siegrist et al. (2005). However, we cannot think of any reason why public perception in Switzerland should have completely changed within only a few years.

Furthermore, it could be useful to investigate how global spontaneous evaluations, which are measured by the SC-IAT, relate to discrete emotions, which are also commonly used to assess affective reaction toward certain stimuli (Peters & Slovic, 2007). For example, the global negative associations with nuclear power might be primarily related to discrete emotional responses such as fear or anger, while the global positive associations with home appliances might be connected with delight or contentment. One should also take into account, however, that some specific emotional reactions tend be more cognitively constrained than others (Damasio, 1994). Secondary emotions, such as “hope” or “relief,” that involve deliberative, cognitive processes, might be less related to implicit measures than some of the basic emotions, such as “fear” or “anger.”

The present study highlights the importance of affect in risk perception. The results of the implicit measure suggest that risks are evaluated through the experiential system and not only by the analytical system, which holds for laypeople as well as for experts. We therefore argue that risk communication strategies should also focus on affective reactions that are evoked by certain hazards. Most risk communication approaches, however, aim to provide information and knowledge, which address only the analytic system. Future research should evaluate the effect of approaches that focus on affective reactions toward risks. The SC-IAT might help to assess the outcome of such approaches.

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Chapter III

Mobile Communication in the Public Mind:

Insights From Free Associations to Mobile Phone Base Stations

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Manuscript submitted for publication as: Dohle, S., Keller, C., & Siegrist, M. (2009). Mobile communication in the public mind: Insights from free associations to mobile phone base stations.

Abstract

Research indicates that the risks associated with mobile communication are perceived differently by experts, laypeople, and base station opponents. Using a free association method, we analyzed these differences in more detail. In our first study, considerable differences in free associations between experts and base station opponents were found. The prevalence of free associations in a large random sample from the general population was explored via correspondence analysis in a second study. Our research is in line with the affect heuristic that guides risk and benefit assessments, and highlights the role of affect in risk communication.

1. Introduction

According to the World Health Organization (WHO), none of the recent scientific reviews has concluded that exposure to mobile phones' or mobile phone base stations' radiofrequency fields causes adverse health consequences (WHO, 2000). Other public health authorities have come to similar conclusions, e.g., the International Commission on Non-Ionizing Radiation Protection (ICNIRP, cf. Ahlbom, Green, Kheifets, Savitz, & Swerdlow, 2004). Because mobile communication technology is relatively new and is continuously developing, however, some authorities have become concerned about the lack of long-term studies on the possible health effects of this technology. Thus, some authorities have recommended that it should be the subject of further research (Stewart, 2000), and accordingly, research on the topic is still ongoing.

Public perception of risks related to mobile communication often diverges strongly from the experts' view. Many laypeople are worried about serious health consequences, especially from the electromagnetic fields (EMF) generated by mobile phone base stations. Psychometric studies conducted in various countries indicate that the risks attached to mobile communication are perceived as little known by the public and moderately dreadful (Bronfman & Cifuentes, 2003; Siegrist, Earle, Gutscher, & Keller, 2005). Many people believe that mobile phones will turn out to have effects that are unknown today (Sjöberg, 2002). In Europe, 48% of the citizens are concerned about the potential health risks of EMF, and most people erroneously believe that the main source of EMF is mobile communication (European Commission, 2007).

Another study compared health beliefs about mobile phones and mobile phone base stations with health beliefs about other environmental risks (Cousin & Siegrist, 2008). The study revealed that mobile communication evokes fewer health concerns than air pollution and ultraviolet rays, but the concerns were similar to those about EMF generated by power transmission lines. Moreover, the study showed that mobile phone base stations evoked significantly more concern than mobile phones themselves, and that only 27% of all respondents in the sample were not worried about the technologies. Other studies have explored laypeople's beliefs about mobile communication qualitatively (Cousin & Siegrist, 2010b). Laypeople and experts were found to hold different mental models of mobile communication. People from the general population and base station opponents often have knowledge gaps concerning the interaction patterns of mobile phones and base stations. For instance, many people were not aware that the distance from the base station has an influence on the level of EMF emitted by a mobile phone: when the caller is far away from the next mobile phone base station, the mobile phone has to increase its output power to ensure network coverage (Cousin & Siegrist, 2010a, 2010b). Due to this knowledge gap, most people prefer to site base stations outside living areas (Cousin & Siegrist, 2010a), which may result in even more radiation for the phoning population.

1.1. The Affect Heuristic

Knowledge deficits of laypeople are commonly assumed to be why experts and laypeople often disagree when it comes to perceived levels of risks. But the causes of these differences seem to be manifold: self-selection, perceived control, or familiarity have been suggested as possible reasons why expert and public perception diverges (Sjöberg, 2002).

Recently, it has been demonstrated that expert–laypeople's differences in the perception of mobile communication risks are also due to differences in automatic affective reactions toward the technology (Dohle, Keller, & Siegrist, 2010). In this study, a Single Category Implicit Association Test (SC-IAT) was used. The SC-IAT is a computer-based categorization task designed to measure the strengths of association among concepts in memory (Karpinski & Steinman, 2006). The implicit test is based on reaction times, and does not require introspection on the part of the subject. The study conducted by Dohle and colleagues (2010) showed that experts immediately attached positive concepts to mobile phone base stations. Opponents, on the other hand, showed a negative SC-IAT effect for base stations; for laypeople, the SC-IAT effect was neutral. Thus, the study indicated that experts and opponents have strong affective reaction to mobile phone base stations.

These results are in line with the affect heuristic (Alhakami & Slovic, 1994; Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic, Finucane, Peters, & MacGregor, 2002, 2004). In this framework, it is hypothesized that individuals use affect as a shortcut within decision making because this is more efficient and easier than weighing all the available pros and cons of different options—especially when decisions are complex or mental resources are limited (Slovic et al., 2002). More specifically, the affect heuristic assumes that people rely on an affect pool during decision making. This affect pool contains all the negative and positive markers associated with images (perceptual and symbolic representations) of objects and events. Taken together, the affect heuristic suggests that people do not rely only on cognitive factors (such as knowledge) to determine whether, for instance, mobile phones and their base stations are safe or not but largely rely on affective factors.

While the implicit measure used in the study by Dohle et al. (2010) gives insights about the positivity and negativity of the mobile communication images people have in mind, little is known about the images of the affect pool itself. Knowing these images would help to understand why experts, laypeople, and opponents differ in their spontaneous evaluations of mobile communication, and such images might be explored using a free association method.

1.2. Free Associations to Mobile Communication

Free associations are the first words or images that come to a person's mind in response to a certain cue (thinking about the word "beach," for example, may bring up associations such as "water," "sand," or "vacation"). Since Galton's (1879) pioneering work, whose systematic investigations mark the beginning of the experimental study of free word association, researchers have developed and refined the free association technique in order to gain more insight into the relationship and frequency of free associations (e.g., Szalay & Deese, 1978).

In the field of risk research, free associations are typically studied in a two-step approach. In the first step, respondents are asked to indicate the words or ideas that come to mind in response to the cue. As a precondition, these responses should arise spontaneously and not be influenced by the researcher. After indicating one or more associations, respondents are instructed to evaluate each association on a scale ranging from negative (e.g., -5) to positive (e.g., +5). The mean values of these ratings can be viewed as indicators of the affect evoked by a certain hazard.

The technique has been successfully applied to explore various risk topics, such as adolescent health-threatening behaviors (Benthin et al., 1995), nanotechnology (Siegrist, Cousin, Kastenholz, & Wiek, 2007), mobile phone base stations (Siegrist et al., 2005), HIV/AIDS (Goodwin et al., 2003), nuclear power and nuclear waste repositories (Peters & Slovic, 1996; Slovic, Flynn, & Layman, 1991; Slovic, Layman, & Flynn, 1991), global warming and climate change (Leiserowitz, 2005, 2006; Lorenzoni, Leiserowitz, Doria, Poortinga, & Pidgeon, 2006), as well as blood transfusion (Finucane, Slovic, & Mertz, 2000).

Compared to traditional methods such as surveys or opinion polls, the free association technique allows tapping into unfiltered, idiosyncratic, and spontaneous meanings associated with a hazard, minimizing the researcher bias (Goodwin et al., 2003; Leiserowitz, 2005, 2006). As another advantage, the free association technique as described above not only provides information about which word associations are connected most frequently with a certain hazard but also provides a numerical value indicating positive or negative affect. This value (i.e., the affective rating of the hazard) can then be connected to other psychometric variables measuring risk perception, attitudes, or behavioral intentions. For instance, in the study by Slovic, Layman, et al. (1991), respondents were asked to associate freely about the phrase “nuclear waste repository” and frequently mentioned words such as “dangerous” or “danger,” “death,” and “pollution”; positive words, however, accounted for only 1% of all word associations. Moreover, the researchers were able to show that the affective rating of those images was related to the perception of the likelihood of possible accidents and predicted rejection of a repository.

1.3. The Present Studies

People who want to minimize risks from radiation emitted by mobile communication should ensure that network coverage is adequate when phoning, which is the case when a base station is close to the caller (Cousin & Siegrist, 2010a, 2010b). Thus, compared to other hazards, mobile phone base stations should be approached rather than avoided in order to minimize risks. Many people, however, feel discomfort in the vicinity of a base station, which is reflected in their spontaneous reactions to base stations (Dohle et al., 2010).

Thus, knowing free associations related to mobile phone base stations would be useful for risk communication. This knowledge would provide an indication why many people fear mobile phone base stations (in contrast to phones). A study conducted by Siegrist et al. (2005) indicated that mobile phone base stations primarily evoke negative free associations (such as electric smog, irradiation, and similar concepts) but fewer negative associations than for gene technology or nuclear waste repositories. Free associations related to mobile phone base stations (which can be counted and compared based on their frequencies) and their relation to risk perception and demographic variables are not known in all particulars, however.

In addition, it would be interesting to investigate whether experts have images in mind when they think of mobile phone communication that are different from those of base station opponents or a randomly chosen sample of laypeople. Since media reports on the topic tend to report only results indicating negative health effects (Elvers, Jandrig, Grummich, & Tannert, 2009), it can be expected that laypeople or base station opponents frequently mention related images. In this sense, this study would yield insights for developing a mutually comprehensible language between experts and laypeople, and help to achieve reciprocal understanding.

2. Study 1: Free Associations of Experts, Lay People, and Base Station Opponents

It seems reasonable to assume that the content and affective ratings of free associations related to base stations are different for experts and laypeople. First, a number of researchers have demonstrated that experts and laypeople differ in their risk perception (Fischhoff, Slovic, & Lichtenstein, 1982; Kraus, Malmfors, & Slovic, 1992; Savadori et al., 2004; Sjöberg, 1998; Thomson, Onkal, Avcioglu, & Goodwin, 2004). Furthermore, people who are strongly opposed to mobile phone base stations may think of different concepts than experts or randomly chosen laypeople, because research indicates that opponents hold strong negative affective reactions toward mobile phones (Dohle et al., 2010). Base station opponents also differ from laypeople in regard to knowledge. Opponents are often more familiar with base station and mobile phone properties than unversed laypeople (Cousin & Siegrist, 2010b).

Study 1 was designed to explore these hypothesized differences among experts, laypeople, and base station opponents in more detail. To avoid confounding, the three groups were matched according to age, gender, and education.

2.1. Method

2.1.1. Participants

Sixty-three persons from the German-speaking part of Switzerland participated in the study. Twenty-one were experts on mobile phone communication. The experts had different backgrounds on the topic: 6 indicated that they were working in the field of basic EMF research, 7 in the field of applied EMF research, 4 in general risk research, 5 for federal authorities, 7 for a cantonal or municipal authority, and 1 for a consumer protection board (multiple answers possible). The experts had, on average, 10 years’ experience with the topic non-ionizing radiation (*M* = 9.86, *SD* = 4.43), and all but 1 stated that they regularly read scientific publications about it. Each expert was matched to a base station opponent (*n* = 21) and a person from the general public (*n* = 21). The matching criteria were gender, age (± 5 years), and self-reported education (five levels: primary school, lower secondary school, upper secondary vocational school, upper secondary university-preparation school, and college or university).

Opponents were recruited via Internet platforms of citizens' action committees and, within the committees, by word of mouth. Laypeople were randomly drawn from the electronic telephone directory. Similar to the opponents, the laypeople were first called and asked about their age and educational background in order to find adequate matches. If the criteria were fulfilled, appointments were made at the participant's home or office.

The average age of the participants was 51 years (*SD* = 8.60). Participants were well educated, 95% (*n* = 60) having completed college or university, and the remainder (5%; *n* = 3) having completed upper secondary vocational school. Seventy-six percent (*n* = 48) of the participants were male, and 24% (*n* = 15) were female.

2.1.2. Measures and Procedure

Participants were asked to associate freely about the concept "mobile phone base station". More precisely, they were asked to indicate the first three thoughts or images that came to mind when they thought about mobile phone base stations. The question appeared on the screen of a portable computer (Lenovo 1.8 GHz dual core ThinkPad using Inquisit software), and participants were instructed to write down their responses in a textbox on the screen. Afterward, each association was presented again on the screen, and the participant rated his or her association on an 11-point scale ranging from *extremely negative* (-5) to *extremely positive* (+5).

2.2. Results

2.2.1. Affective Rating of Free Associations

The affective rating of the associations related to mobile phone base stations was, overall, negative (*M* = -1.95, *SD* = 2.04). Taking the mean of all three expert affective ratings, the results indicate that associations from the expert group were negative to a small extent (*M*

= -0.92, *SD* = 1.21, *n* = 21). Participants from the lay sample mentioned words and images that were slightly more negative than the experts' associations (*M* = -1.40, *SD* = 1.60, *n* = 21). The affective ratings of the base station opponents were the most negative (*M* = -3.52, *SD* = 2.20, *n* = 21). A repeated measures analysis of variance (ANOVA) showed that the three groups differed in the affective rating of their associations, $F(2,60) = 13.70$, $p < .01$. Post hoc tests (Tukey's *honestly significant difference* [HSD]) revealed that the affective ratings of the base station opponents differed from those of the laypeople and the expert sample (both: $p < .01$). Expert affective ratings did not differ from those of the laypeople, however ($p > .6$).

2.2.2. Content of Free Associations

Each participant expressed three word-association images. These 189 associations were assigned to 28 subcategories by a first rater. A second rater verified the subcategory assigned to each association. Interrater reliability (Cohen's kappa) was very good ($\kappa = .80$).

Afterward, the subcategories were subsumed under 10 general categories. As illustrated in Table 3.1., the general category negative consequences was most dominant. Thirty-nine out of 63 participants (62%) mentioned at least one free association belonging to this category, and the affective rating of this category was, on average, negative. Subcategories belonging to the general category negative consequences were, for example, electric smog, conflicts and discussions, or environmental aspects. The subcategory with the most negative rating within the general category negative consequences was health aspects (*M* = -3.77, *SD* = 1.74). Examples of the specific associations that were mentioned by participants are listed in Table 3.1..

Two other general categories that were mentioned frequently were radiation and esthetic aspects. Twenty-three participants (37%) stated at least one association that belonged to the category radiation, and 22 participants (35%) mentioned an image associated with esthetic aspects. Both general categories were rated clearly negative as well. Associations related to technical concepts were raised by 18 participants (29%) and included images such as "transmitter" and "magnet." Positive concepts and technical concepts were the only two general categories that were judged to be slightly positive. Other frequently mentioned associations belonged to the category negative concepts or synonyms or repetition of the word "base station" (which were both rated negatively), or were assigned to the miscellaneous category.

Table 3.1. Frequency and Affective Ratings of Free Associations to the Term “Mobile Phone Base Station” (Study 1)

Category	Experts		Laypeople		Opponents				
	n	*M (SD)*	*n*	*M (SD)*	*n*	*M (SD)*	*n* (total)	*M (SD)* (total)	Examples
Negative consequences	11	-2.50 (1.20)	11	-2.18 (2.37)	17	-4.06 (1.36)	39	-3.09 (1.84)	"electric smog," "carcinogen"
Radiation	4	-1.75 (2.06)	10	-2.10 (1.91)	9	-3.78 (2.73)	23	-2.70 (2.36)	"radiation in air," "high frequency radiation"
Esthetic aspects	6	-3.25 (0.76)	7	-3.29 (1.25)	9	-2.44 (3.68)	22	-2.93 (2.43)	"ugly," "view of a place"
Technical concepts	8	0.67 (2.06)	8	1.38 (2.39)	2	-5.00 (0.00)	18	0.35 (2.83)	"transmitter," "magnet"
Negative concepts	2	-2.25 (1.06)	6	-0.75 (2.86)	8	-4.42 (0.77)	16	-2.77 (2.49)	"fear," "problem"
Miscellaneous	5	2.00 (1.58)	2	0.00 (5.66)	4	-4.00 (1.15)	11	-0.55 (3.56)	“future,” “air”
Synonyms	7	-0.07 (0.73)	3	-0.67 (0.58)	0	---- (----)	10	-0.25 (0.72)	"antenna," "mast"
Location	4	-0.25 (2.50)	4	-2.50 (2.08)	1	-5.00 (----)	9	-1.78 (2.59)	“skyscraper,” “public buildings”
Positive concepts	2	3.00 (0.00)	3	0.00 (2.00)	3	1.33 (2.31)	8	1.25 (2.05)	“necessary,” “mobility”
Political and societal aspects	3	-1.67 (0.58)	2	0.00 (2.83)	2	0.00 (7.07)	7	-.71 (3.25)	“political,” “citizens' initiative”

Note. *n* = number of participants who mentioned at least one association that belonged to the particular general category. For participants mentioning more than one association of the same general category, the mean was taken as an indicator for the affective rating of the category.

2.2.3. Differences in Free Associations Between Matched Groups

There were considerable differences in the frequency and the affective ratings of the associations among the three groups. As illustrated in Table 3.1., base station opponents more often mentioned associations that belonged to the general category negative consequences than experts or laypeople. Logistic regression was used to test whether the group would predict the presence or absence of associations belonging to this category. For this purpose, a dummy variable was calculated that indicated the presence or absence of a response in the category negative consequences. The logistic regression for the overall model was marginally significant, $\chi^2(2, N = 63) = 5.15$, $p = .08$, Nagelkerke $R^2 = .11$. Indicator contrast with the lay group as the reference category showed that laypeople did not differ from the expert group ($p = 1.00$) but were marginally different from the opponent group, $B = 1.35$, Wald = 3.66, Exp(B) = 3.86, $p = .06$. The three groups also varied in the affective rating of the associations belonging to the category negative consequences, $F(2, 36) = 5.19$, $p = .01$. Post hoc tests (Tukey's HSD) indicated that participants from the opponent group rated negative consequences associations more negatively than either the expert group or the lay group (experts: $p = .05$, laypeople: $p = .02$).

Group was also a significant predictor for the presence or absence of associations belonging to the category technical concepts, $\chi^2(2, N = 63) = 6.35$, $p = .04$, Nagelkerke $R^2 = .14$. Here again, the lay group (indicator) differed from the opponent group ($B = -1.77$, Wald = 4.13, Exp(B) = 0.17, $p = .04$) but not from the expert group ($p = 1.00$). A similar pattern was found for the affective rating of the technical concepts associations. Results of the ANOVA indicated that there were differences between groups, $F(2, 15) = 7.18$, $p = .01$, and a post hoc test showed that the opponent group had a more negative rating of those associations than either experts or laypeople (both: $p = .01$).

In addition, the presence or absence of the category negative concepts was marginally significantly predicted by group, $\chi^2(2, N = 63) = 5.15$, $p = .08$, Nagelkerke $R^2 = .12$. Neither the expert group ($p > .1$) nor the opponent group ($p > .5$) differed significantly from the lay group (indicator), suggesting that this difference was due to expert–opponent differences. Moreover, the affective rating of the associations belonging to the general category negative concepts varied among the groups, $F(2, 13) = 6.58$, $p = .01$; the opponent group associations were more negative than those of the laypeople ($p = .01$), according to post hoc tests. Furthermore, the affective rating of the category miscellaneous was different among the groups as well, $F(2, 8) = 7.02$, $p = .02$. This significant effect was due to expert–opponent differences ($p = .01$).

For all other general categories, no significant relationship was found between group and the presence or absence of a particular category ($p > .1$) or the affective ratings ($p > .2$) of the category[1].

2.3. Discussion

The aim of Study 1 was to examine whether experts, laypeople, and base station opponents (who were matched according to gender, age, and education) would differ in their free associations related to the term mobile phone base station. The present findings indicate that the three groups differ in the frequency of associations belonging to the categories negative consequences, negative concepts, and technical concepts. While the base station opponents primarily thought more often of negative consequences and negative concepts than laypeople or experts (and rated those associations more negatively), the latter more often mentioned the technical concepts of mobile phone base stations (and rated these associations more positively). “Radiation” was mentioned slightly less often by experts, but no statistical relationship between group and frequency of associations was found. “Esthetic aspects” were generally mentioned often, independent of group membership, and were rated similarly by experts, laypeople, and opponents.

In contrast to other studies (Fischhoff et al., 1982; Kraus et al., 1992; Savadori et al., 2004; Sjöberg, 1998; Thomson et al., 2004), we found no significant differences between the experts and the unversed laypeople, either in the frequency of the categorized associations or in the affective rating of these associations. Group variations seem to be driven by differences between the opponent group, on the one hand, and the experts and laypeople, on the other. In our study, experts and laypeople were matched according to age, gender, and education, because studies of expert–laypeople differences in risk judgments have often been criticized for being inconclusive about whether differences in risk perception are due to expertise per se or to sociodemographic characteristics (Rowe & Wright, 2001). Thus, expert–laypeople differences, as found in other studies, might frequently be confounded. It should be noted, however, that, due to the complex matching procedure, the subsample sizes in our study were relatively small. Therefore, it is possible that differences between experts and laypeople might

[1] The category synonyms had a cell frequency < 1, so logistic regression and analysis of variance couldn’t be applied.

be detected in studies with greater statistical power. Presumably, the present study revealed only the most prominent differences among the three groups.

Furthermore, the findings show that, overall, participants primarily utter associations that have a negative meaning for them. Of all general categories, only two categories were rated as slightly positive (i.e., technical concepts and positive concepts). The results also emphasize the fact that participants most often think of the negative consequences of mobile phone base stations; almost two-thirds of the participants mentioned associations connected with this aspect. Taken together, the results of Study 1 underline that, despite some differences in the frequency and affective rating of the associations among the three groups, the majority of the associations was negative in all groups.

3. Study 2: Free Associations of a General Population

Study 2 was conducted in order to discover systematic patterns in the free associations produced by a large, randomly drawn sample of the general population. The study was aimed at providing information about the prevalence of free associations evoked by the term mobile phone base station and about the affective rating of those associations. Because of the large sample size, this study allowed us to analyze the frequencies of free associations on a subcategory level—in contrast to Study 1, in which only general categories were explored. Furthermore, in Study 1, the lay sample was matched to the expert sample. Respondents were therefore predominantly male and highly educated. Thus, the sample was not suited to drawing generalizable conclusions about which word associations are connected most frequently with the term mobile phone base station.

In order to explore the frequencies of associations, a correspondence analysis was applied in Study 2. Correspondence analysis is a powerful tool to represent the relations among two or more sets of variables (Weller & Romney, 1990). This analysis has been associated mainly with Jean-Paul Benzécri and his research group in France (Le Roux & Rouanet, 2004), and became more and more popular in the 1980s with the publication of English textbooks on this topic (Greenacre & Blasius, 2006). Data input for correspondence analysis is typically a two-way contingency table. The objective of correspondence analysis is to reduce the dimensionality of the table and to visualize it in a space of low dimensionality (Nenadic & Greenacre, 2007). Thus, correspondence analysis facilitates the interpretation of complex contingency tables, since this analysis replaces the raw data with a more simple data matrix (Clausen, 1998; Greenacre & Blasius, 2006). A comprehensive theoretical overview of correspondence analysis can be found in the work of Greenacre and Blasius (2006). In our study, correspondence analysis was used to study the connections between the free associations with mobile phone base station on the one hand and risk perception on the other.

3.1. Method

3.1.1. Participants

The survey was carried out in the urban area of Zurich, Switzerland, between November 2008 and March 2009. The randomly selected households (drawn from the electronic telephone directory) were contacted by mail requesting cooperation with the survey. Approximately 1 week later, a trained interviewer telephoned them, and the person answering the phone was asked to participate in the study. If this person agreed to participate, the interviewer made an appointment at the person's home. The face-to-face interview, which addressed several issues of mobile phone communication, lasted 1 hour on average. The response rate was about 35%.[2]

Participants (N = 503) were between 18 and 80 years of age. The distribution of age (M = 51.60, SD = 15.10) and gender (45% female, 55% male) indicated that males and older people were slightly overrepresented, compared to the general Swiss population (BFS, 2009). The self-reported education level ranged from primary or lower secondary school (6%; n = 28) through upper secondary vocational school or upper secondary university-preparation school (58%; n = 294) to college or university (36%; n = 178). Ninety-four percent of the participants (n = 470) were mobile phone owners, using their mobile phone 26.04 (SD = 60.76) times per week for communication purposes. Due to a computer error, the free associations of 3 participants were missing. Furthermore, 3 other participants refrained from filling out the questionnaire that was presented at the end of the interview.

3.1.2. Measures and Procedure

Free Associations. In the first part of the interview, participants were asked to associate freely about the term mobile phone base station. The same free association

[2] The response rate was calculated as: Response rate = (number of completed interviews)/(number in sample-number not eligible).

technique described in Study 1 was applied. The question appeared on a computer screen, and respondents typed in the first three associations that came to mind. Subsequently, the respondents rated the association on a scale ranging from *extremely negative* (-5) to *extremely positive* (+5).

Questionnaire. Risk perception of mobile phone base stations was measured in a paper-and-pencil questionnaire, which was administered at the end of the interview. The item was worded in the following way: “How risky do you consider mobile phone base stations to be for Swiss society as a whole?” It was answered on a 6-point scale ranging from *low risk* (1) to *high risk* (6). On the final page of the questionnaire, demographic data regarding age, gender, and education were collected.

3.2. Results

3.2.1. Affective Rating of Free Associations

First, the affective rating of the three associations as judged by participants was analyzed. Not only was the participants’ affective rating of the first association clearly negative (M = -1.80, SD = 3.00) but also the second (M = -1.47, SD = 2.94) and third associations (M = -0.89, SD = 3.04) were judged to be negative. The affective rating of all three associations differed significantly from the scale’s midpoint ($p < .001$). According to a linear contrast revealed through a repeated measures ANOVA, the affective rating of the associations increased significantly from the first to the last association, $F(1,499) = 31.24$, $p < .001$. A linear regression was used to regress risk perception on the three affective ratings. The first ($\beta = -.22$, $p < .001$), the last ($\beta = -.16$, $p < .001$), but not the second ($\beta = -.07$, $p > .10$) affective rating predicted risk perception significantly ($R^2 = .12$).

3.2.2. Content of Free Associations

The same general categories and subcategories used in Study 1 were used to categorize the words and images expressed by the participants. However, due to the larger number of associations (N = 1,500), we added three subcategories that were not present in the first study: acceptance, provider, and not-in-my-backyard beliefs (NIMBY). These subcategories were assigned to the preexisting general categories positive concepts, technical concepts, and location, respectively.

Table 3.2. Frequencies of Free Associations to the Term "Mobile Phone Base Station" in a General Population Sample (Study 2): General Categories and Subcategories (Indented)

Categories	**Frequencies**
Negative consequences	370
Health aspects	139
Number of base stations	60
Electric smog	49
Conflicts and discussions	44
Environmental aspects	42
Hazard	36
Esthetic aspects	241
Esthetic aspects	241
Radiation	227
Radiation	227
Positive concepts	164
Necessity	114
Acceptance	32
Usefulness	18
Negative concepts	143
Problem	57
Insecurity	31
Negative emotions	24
Invisibility	18
Senselessness	13
Technical concepts	103
Technical concepts	86
Provider	9
Mobile phones	8
Political and societal aspects	76
Coordination	28
Initiatives and rejections	25
Political aspects	23
Location	74
Location: General	42
Location: Building	25
NIMBY	7
Synonyms	58
Synonyms	58
Miscellaneous	44
Miscellaneous	17
Future	9
Communication	8
Camouflage	7
Science	3

A subsample of the associations (n = 150) was coded and assigned to the subcategory by a second rater. Interrater reliability (Cohen's kappa) was again very good (κ = .83). A complete list of all general categories and subcategories and their frequencies is given in Table 3.2.

The general category negative consequences was most dominant. Almost every fourth association belonged to it; within this category, participants mentioned health aspects (9%) most frequently. In addition, more than 16% of the associations belonged to the category esthetic aspects and 15% to the category radiation. Positive concepts were also mentioned regularly (11%), which were primarily covered by the subcategory necessity (7%). The NIMBY phenomenon, which was added in Study 2, occurred only rarely (0.005%).

3.2.3. Correspondence Analysis

Subcategories were further analyzed with a correspondence analysis. The data input for the correspondence analysis was a contingency table that included the 31 free associations categories (columns) and three different levels of risk perception (rows). The risk perception scale was used to divide participants into three groups: low-, medium-, and high-risk perception (scale points 1 and 2, 3 and 4, and 5 and 6, respectively).

In addition, the demographic variables age, gender, and education were used as supplementary elements (i.e., as additional rows in the contingency table to describe the free association categories). Supplementary elements do not determine the solution space but rather support the interpretation of the geometric orientation and serve as a validity check (Clausen, 1998; Greenacre, 2006). The continuous variable age was divided into four groups (participants younger than 30 years, between 31 and 45 years, between 46 and 65 years, older than 65 years). Likewise, the variable education was divided into two groups: low education (primary, lower secondary, or upper secondary vocational school) and high education (upper secondary university-preparation school and college or university).

Applying correspondence analysis to this table yielded the graphic display shown in Figure 3.1. The display indicates a two-dimensional joint space that represents the columns and rows of the contingency table. The first dimension explains 73%, and the second 27% of the variance. The overall chi-square was $\chi^2(60) = 9.22$, p = .005, and total inertia was λ_G = 0.066.

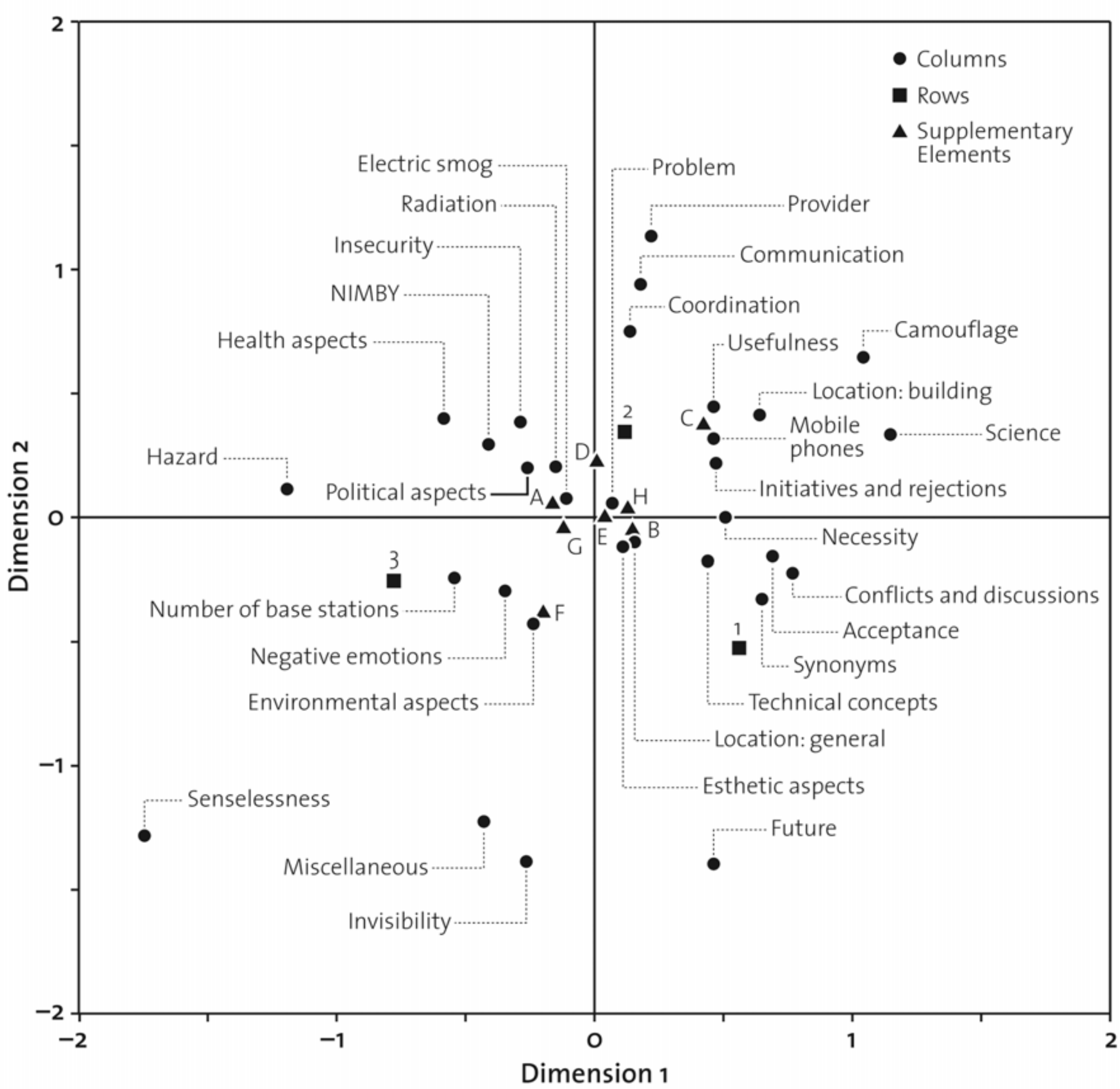

Figure 3.1. Bidimensional graphic representation of the correspondence analysis. Risk perception: 1 = *low risk*, 2 = *medium risk*, 3 = *high risk*. Gender: A = females, B = males. Age: C = < 30 years, D= 31-45 years, E = 46-65 years, F = 65+ years. Education: G = low education, H = high education.

The interpretation of the graphic display is based on the proximity of the points: two points that are close together are closely related or similar, and two points apart are less closely related or dissimilar (Weller & Romney, 1990). Thus, the interpretation of the display consists in inspecting how the free association categories lie relative to one another and how the different levels of risk perception are spread out relative to the free association categories.

It is also common practice to study the distribution of the points along the dimensions in order to interpret the dimensions (Clausen, 1998).

The first dimension illustrates the difference in risk perception. Participants with low-risk perception often mentioned associations that belonged to the categories science, camouflage, conflicts and discussions, acceptance, or location on building, or they thought of synonyms. Participants with high-risk perception, on the other hand, mainly mentioned associations such as senselessness or hazard. They also thought about health effects and the number of base stations, and mentioned NIMBY concepts.

On the second dimension, young and old people are slightly directed toward each end of the dimension. Young adults tended to think about the providers, communication, and the coordination of mobile phone base stations. This group is also directed toward the low-risk end of the first dimension. Older people mentioned invisibility and senselessness, but the category future also lies in the direction of older age groups. Moreover, older participants were located slightly toward the high-risk end of the first dimension. Concerning the other supplementary elements, Figure 3.1. shows that female and less-well-educated participants were located slightly toward the negative end of the first dimension, which represents a higher risk perception, while male and better-educated participants are located slightly toward the positive (low-risk) end of the first dimension. It is important to note, however, that all supplementary elements (and gender and education in particular) are situated near the centroid, i.e., the origin of the coordinate system. Thus, they contribute only a little to the difference between high- and low-risk perception.

3.3. Discussion

In Study 2, data from a large Swiss survey were analyzed in which free associations related to mobile phone base station were collected. The results showed that, on average, participants rated their own associations slightly negatively, which is line with results obtained by Siegrist et al. (2005).

Especially the first association that came to the participants' minds was negative, and became less negative in the second and third responses. It is possible that the participants wanted to balance their first negative association with a more positive one, and that neutral or positive associations occurred to the participants only after some time of reflection. In this regard, our study differs from a free association study conducted by Lorenzoni et al. (2006).

In their study on climate change, the mean affect in one of their samples became progressively more negative in the second and third responses. Differences in the two studies might be due to methodological factors, however. In Lorenzoni et al.’s (2006) study, participants were free to express fewer than three associations, and it is possible that only concerned people expressed second and third associations, which may have inflated the negativity of the last associations.

The results further indicated that the affective ratings were related to risk perception. Risk perception was predicted by the affective rating of the first and the last associations, indicating that not only the first spontaneous and immediate association but also more deliberative associations are important predictors of risk perception.

The free associations were categorized and assigned to 31 subcategories and 10 general categories. As in Study 1, negative consequences was the most prevalent general category, while esthetic aspects and radiation were also quite dominant. NIMBY beliefs were added in Study 2, but occurred only rarely. Interestingly, they were slightly rarer than NIMBY beliefs in regard to a nuclear waste repository (Slovic, Flynn, et al., 1991), although people are presumably more often confronted with the construction of or the request to built a base station in their vicinity.

Furthermore, a correspondence analysis indicated that people who differ in their risk perception also have different images and words in mind when they think of mobile phone base stations. Respondents who assigned high risks to base stations often noted that they are senseless and a hazard that may lead to health effects. The rarely occurring NIMBY beliefs were also primarily brought up by participants with high-risk perception. Respondents with low-risk perception, on the other hand, often mentioned concepts that are less affective. Similar to the experts in Study 1, the respondents simply noted synonyms (“mast”), for instance. They also mentioned associations that belonged to the category conflicts and discussion; however, it cannot be determined whether these respondents were referring to their own conflicts or whether they drew on discussions in the media and by base station opponents. The demographic variables age, gender, and education were only slightly connected with differences in free associations and risk perception.

4. General Discussion

In the free association technique, a person reports anything that may cross his or her mind in response to a certain cue. The method allows categorizing of unfiltered, idiosyncratic responses, which may differ substantially among groups of people. A subsequent rating of the associations allows the investigation of differences in the affective quality of those associations, and can be related to other psychometric variables. Thus, the technique combines a qualitative approach (the content of the associations) with a quantitative approach (the affective rating of the associations).

The affective rating of the free associations differed significantly between experts in mobile communication and people who were clearly opposed to mobile communication. This is in line with a reaction time study conducted by Dohle et al. (2010), which found that experts, base station opponents, and laypeople differ in their spontaneous affective evaluations of mobile phone base stations. The content of the free associations, as provided in the present research, provides insights into the causes of such differences. We found, for instance, that experts often think of technical concepts, while opponents think of the negative consequences and negative concepts of base stations. Remarkably, differences were primarily found between experts and base station opponents, but not between experts and randomly selected laypeople. However, all groups agreed upon the negative visual impact of base stations.

Esthetic aspects were also mentioned frequently in the second study, in which a large sample from the general population was surveyed. The focus of the second study was to explore differences between participants who attribute high or low risks to mobile phone base stations. Compared to the low-risk group, participants from the high-risk group more often mentioned highly affective images or words such as “hazard” or “senseless.” Health aspects were frequently expressed in this group as well, which might be a reflection of media reports on the adverse health effects of mobile communication.

The results of our study support the idea of the affect heuristic, according to which people consult an affect pool during decision making, which permits an easier and more efficient decision-making process (Finucane, Alhakami, et al., 2000). We believe that the free association technique is a way of exploring the contents of this affect pool. This is in line with the notion that implicit associations are simply a different description of the affect pool (Spence & Townsend, 2008). Implicit measures, however, give insights only into whether a certain cue is more strongly associated with positivity or negativity. The free association method, in contrast, goes beyond assessing spontaneous evaluation and elicits the specific images that are most frequently connected with, e.g., a certain hazard.

This study also has some limitations that have to be addressed. First, due to the small subsample sizes in Study 1, only the most prominent group differences in free associations could be detected. Moreover, with the results of our studies, we can only speculate about the development of differences between experts and base station opponents in free associations about mobile phone base stations. It might be the affinity for technology, and less the scientific knowledge about a technology, that resulted in more positive affective ratings from the experts. It has been noted that the affect heuristic literature says relatively little about how the positive and negative tags of the affect pool are developed (Spence & Townsend, 2008). For mobile communication, it seems reasonable to assume that laypeople's and opponents' associations are influenced by media reports, because people are often uncertain how to integrate and evaluate scientific results on this technology. Future research might want to address this assumption in an experiment or a quasi-experiment, in which participants receive pro and con messages (as carried out by Rodriguez, 2007, for instance) on a certain topic. Such an experimental setting might reveal whether spontaneous affective reactions (assessed with implicit measures) or free associations change after receiving one-sided messages, or whether the reactions remain stable and unaltered.

In a similar vein, it might be interesting to see if free associations related to mobile phone base stations change over time. As noted by Elvers and colleagues (2009), there is a trend in media publication style that can be described as "from amplification to information": journalists have switched over to acknowledging the existence of scientific uncertainty and provide more detailed information on the topic. This switch might also become noticeable in the public's free associations with the topic after some time.

For the dialog among experts, laypeople, and base station opponents, the findings of our research suggest that communication should not be constructed as a one-way transfer of information (Davies, 2008). Experts and nonexperts seem to have their own idiosyncratic apprehension about the risks associated with mobile communication. A context-dependent, multisided debate that seeks to acknowledge all opinions and apprehensions, as described by Davies (2008), would be desirable in this regard. Furthermore, affective variables in general seem to play an important role in risk perception and communication. Lee et al. (2005) pointed to the fact that affective variables might influence the impact of cognition and vice versa, because in that study emotional responses moderated the effect that knowledge has on people's overall attitudes toward a technology. Following this line of argument, affective responses are central in shaping attitudes and perception. The present study provided evidence that affective factors are important for the perception of mobile communication risks as well.

But experts and opponents, as well as individuals with high- and low-risk perception, do not merely differ in the magnitude of their affective responses to mobile communication. More importantly, what makes people's reactions different from another is that they are based on different images. Thus, this research points to similarities and differences in the conception of mobile communication risks, and provides an indication about why experts and laypeople sometimes seem to talk at cross-purposes. Therefore, we believe that this study provides the first step for an improved mutual understanding among laypeople, opponents, and experts.

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Chapter IV

Fear and Anger: An Emotion-Specific Approach to Risk Judgments

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Manuscript submitted for publication as: Dohle, S., Keller, C., & Siegrist, M. (2009). Fear and anger: An emotion-specific approach to risk judgments.

Abstract

Previous research has shown that broad and unspecified affective reactions can serve as a heuristic in decision making. The present study, in contrast, examines how specific integral emotions influence decisions and judgments. More precisely, the study investigated how fear and anger determine risk and benefit perceptions and the acceptance of a technology. Using structural equation modeling, we found that risk perception of mobile phone base stations was more strongly influenced by fear than by anger. On the other hand, benefit perceptions and the acceptance of mobile phone base stations were primarily determined by anger. In addition, controllability and fairness emerged as important cognitive appraisals for these two emotions. In sum, our findings highlight how specific emotions, rather than global affect, shape decisions in a risk context. Furthermore, the study gives insights into how emotions toward a hazard develop and, thus, how they could be modified.

1. Introduction

According to the affect heuristic, the perception and integration of affective feelings enable individuals to be rational actors in many situations (Slovic, Finucane, Peters, & MacGregor, 2002). Affect can serve as an effective shortcut within decision making, especially when decisions and judgments are complex and cognitive resources are limited. The affect heuristic developed from evidence of early psychometric studies of risk perception, which indicated that feelings of dread play a powerful role in public perception and acceptance of risk. It shares a number of similarities with the *How do I feel about it?* heuristic (Schwarz & Clore, 1988), which arose from social psychology, and with the *somatic marker hypothesis* in the field of neuroscience (Damasio, 1994).

In the theoretical framework of the affect heuristic, affect is understood as *goodness* or *badness* experienced as a feeling state, and demarcates a positive or negative quality of a stimulus. According to Slovic and colleagues (Finucane, Peters, & Slovic, 2003; Slovic et al., 2002), affect differs from emotions, and from moods. Affect is more subtle than emotions, and unlike moods, it has a direct motivational effect. This definition of affect differs from traditional conceptualizations of affect, which use affect as a broad and inclusive label to refer to both moods and emotions.

1.1. The Influence of Specific Emotions on Decision Making

The influence of global affect on decision making and risk and benefit perceptions has been demonstrated in various studies (Dohle, Keller, & Siegrist, 2010b; Slovic et al., 2002). Considering affect as conceptually independent from specific emotions and moods involves some ambiguity, however. First, this definition of affect seems to encompass the definition of an attitude (Sjöberg, 2007; Spence & Townsend, 2008). Second, the question arises how affect can be measured (Dohle et al., 2010b; Peters & Slovic, 2007). Peters and Slovic (2007) reported three studies that systematically examined this issue and took the predictive validity of different measures into account. The authors concluded that research with affect should include a holistic, unipolar, discrete emotion (HUE) evaluative measure. The HUE measure is based on discrete emotions such as anger, fear, and happiness. This result calls into question whether affect can be seen as a construct that is detached from other concepts such as emotion. In a similar vein, Zeelenberg and colleagues (Zeelenberg, Nelissen, Breugelmans, & Pieters, 2008) have argued that specific emotions have an important influence on decisions. In their *feeling is for doing* approach, the authors argue that different emotions may produce different behaviors; thus, it necessary to study the effect of emotions to fully understand decision making.

Relatively little research (Peters, Burraston, & Mertz, 2004; Sjöberg, 2007), however, has examined how integral emotions influence subsequent judgments (Dunn & Schweitzer, 2005; Zeelenberg et al., 2008). Integral emotions stem from thinking about the consequences of one's decision, unlike incidental emotions, which are caused by dispositional or situational sources objectively unrelated to the decision problem at hand. Sjöberg (2007) studied the relationship between integral emotions and perceived risk and attitudes. The author found that emotional factors were the most important determinants in explaining attitude toward repository for spent nuclear fuel, followed by epistemic trust, perceived risk, and the general attitude to nuclear power. Peters et al. (2004) investigated the role of integral emotions using an emotion-based model of stigma responses toward radiation. Stigma responses indicate that something is disgraceful, unacceptable in general, and unacceptable under any imaginable circumstances. The authors showed that stigma responses emerged from fear and anger, highlighting their importance for risk judgments. In the Peters et al. (2004) study, fear and anger were subsumed under a negative emotion scale. However, research that examined the influence of incidental emotions on risk perception has shown that fear and anger can have quite different effects on risk estimates and choices (Lerner & Keltner, 2001). Therefore, it seems reasonable to assume that integral fear and anger also have a different influence on risk judgments.

1.2. Emotions and Cognitive Appraisals

Little is known about the antecedents of affect. The affect heuristic literature is relatively sparse on how affect evolves (Spence & Townsend, 2008). An emotion-specific approach may be effective for drawing conclusions about how affective reactions develop and how they can be changed. Appraisal theories of emotion emphasize the causes of emotions. These theories propose that discrete emotions arise from conscious or unconscious processes of evaluation of significant events and of attributions of the causes of those events (Niedenthal, Krauth-Gruber, & Ric, 2006). These appraisals encompass, for instance, the novelty of the stimulus, goal significance, and coping potential. Prior research has identified the appraisal of control, i.e., the perspective that one's own actions can modify the course of events (Frijda, 1986), as particularly important in distinguishing different emotions (Dunn &

Schweitzer, 2005). For example, in his cognitive theory of emotion, Lazarus (e.g., Lazarus & Folkman, 1984) suggested that appraising an outcome as controllable reduces stress and can turn danger from threat into challenge; likewise, absence of control can result in learned helplessness (Seligman, 1975). Another appraisal that is strongly related to control and that might be an important antecedent of emotion is fairness—especially in a risk framework (e.g., Earle & Siegrist, 2008). Smith and Ellsworth (1985) demonstrated that fairness is relevant for appraisals of responsibility and control: if another person is responsible for a certain event or situation, it is seen as less fair than if the person herself or himself is responsible. Likewise, Mikula and colleagues (1998) found that perceived injustice plays a major role in the elicitation of many different emotions, and primarily for anger.

1.3. The Present Study

The present study examines risk perception and acceptance of hazards in an emotion-specific manner. In line with the feeling-is-for-doing approach (Zeelenberg et al., 2008), we assumed that anger and fear may have different influences on risk perception and acceptance of hazards. We hypothesize that risk and benefit perceptions are primarily influenced by fear, because prior research has shown that dread is a major determinant for risk perceptions. Anger, in contrast, should mainly determine the acceptance of a hazard. Sjöberg (2007) found that anger, not fear, was the most important emotion factor in predicting attitude toward a repository. The importance of anger for the acceptance of a risk is also highlighted in Sandman's outrage model (Sandman, 1987).

A second aim of the paper is to explore the causes of emotion in a risk context, and we concentrated on control. We also included fairness, because it is strongly related to control (Smith & Ellsworth, 1985). The relationships between cognitive appraisals (fairness, control), specific integral emotions (fear, anger), acceptance, and risk and benefit perception were investigated with structural equation modeling (see Figure 4.1. for an overview of the proposed model).

The model was tested in the field of mobile communication. We focused on mobile phone base stations, rather than on mobile phones, because research has shown that people often fear mobile phone base stations more than mobile phones, although the actual exposure to radiation can be much higher from mobile phones (Cousin & Siegrist, 2010). Moreover, mobile phone base station risks are also characterized by a loss of control. Human beings cannot perceive nonionizing radiation; citizens therefore have no control about the exposure to a base station's radiation. Furthermore, citizens usually have only a few possibilities to participate in base station siting decisions. Thus, we assumed that mobile communication provides an optimal context for testing the proposed model.

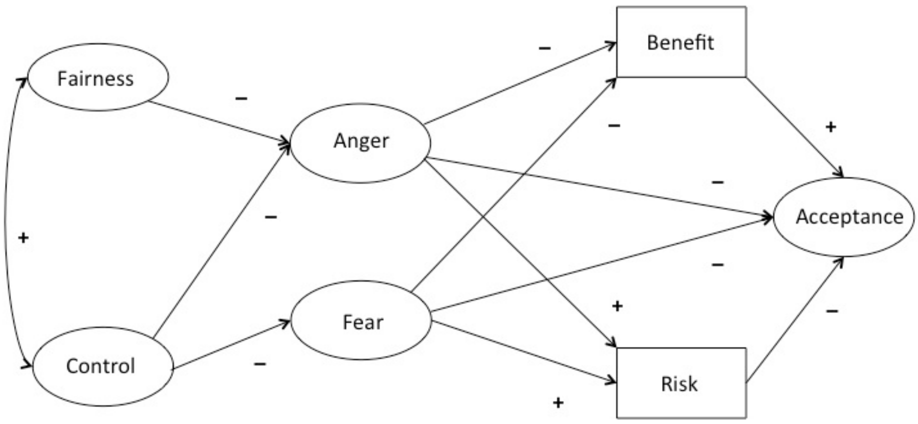

Figure 4.1. Initial (hypothesized) model of determinants of acceptance of mobile phone base stations.

2. Method

2.1. Participants

The data from the present study come from a survey conducted in the urban area of Zurich, Switzerland. A sample of 500 participants, randomly drawn from the electronic telephone directory, was interviewed face-to-face in their homes. The response rate was 35%. Forty-five percent (*n* = 225) of the respondents were female, and 55 % (*n* = 275) were male. The mean age was 51.60 (*SD* = 15.10).

2.2. Materials and Procedure

The paper-and-pencil questionnaire contained a wide range of items on the issue of mobile communication. Table 4.1. shows the 28 variables used for measuring control, fairness, anger, fear, acceptance, and risk and benefit perception. Participants expressed their agreement with each item using a number between 1 (*no agreement at all*) and 6 (*absolute agreement*). The items on perceived risk or benefits of mobile phone base stations were answered on a scale ranging from 1 (*low risk or benefit*) to 6 (*high risk or benefit*).

The items for measuring acceptance stem from the work of Siegrist, Earle, and Gutscher (2003). New items were formulated to measure the variables on perceived control, fairness, anger, fear, risk and benefit perception. For the variable control, questions assessed control of radiation (V1 to V4) and control of construction (V5 and V6). For anger, four items were formulated using the word *angry* (V15 to V18), and four items used the word *annoyed* (V19 to V22).

2.3. Data Analysis

Structural equation modeling procedures were used to test the plausibility of the postulated causal model. AMOS 17.0 (SPSS Inc.) was used for estimating parameters. Analysis was based on raw data, and the maximum likelihood (ML) method was employed. Assessment of model fit was based on the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the meaningfulness of the model (Hu & Bentler, 1995).

Ninety-eight percent (n = 488) of the respondents answered all questions used to test the causal model; 2% (n = 10) had one missing value, and 0.4% had two missing values (n = 1) or three missing values (n = 1). The SPSS data imputation procedure was utilized. Missing values were replaced using a procedure based on the EM algorithm. Variables referring to a particular latent variable were used as predictors of the missing value estimates of these variables.

Before we estimated the structural model, we employed confirmatory factor analysis to test whether the postulated measurement model was appropriate. All factor loadings were significant ($p < .001$) and substantial ($a > .40$ or $a < -.40$). Furthermore, the factor loadings indicated that the eight items assessing anger measured the same construct.

To analyze the structural model, i.e., the relationships between the latent variables, modification indices were employed to identify which parameters could be added to improve the fit of the model. Because subsequent models are nested, the difference in χ^2 was used to assess the improvement of the fit of the new model.

Table 4.1. Measurement Scales, Cronbach's Alpha, and Standardized Factor Loadings for Indicator Variables

Factors and variables	Factor loadings (a)
Control; $\alpha = .91$	
V1 I would feel more comfortable if I could protect myself against the radiation emitted by a mobile phone base station.[a] (R)	.81
V2 I suffer from the fact that I cannot control the radiation emitted by a mobile phone base station. (R)	.83
V3 The worst thing about the radiation emitted by a mobile phone base station is that I am exposed to it without any possibility of controlling it. (R)	.88
V4 If I could somehow control the radiation of a mobile phone base station, I would feel better. (R)	.81
V5 I feel helpless when I hear that a new mobile phone base station will be constructed. (R)	.70
V6 The fact that new mobile phone base stations are constructed everywhere leaves me with a sense of helplessness. (R)	.72
Fairness; $\alpha = .81$	
V7 Concerning mobile phone base stations, I sense that I am treated fairly.[a]	.64
V8 I think there is a lot of unfairness about mobile phone base stations. (R)	.63
V9 Overall, I think that I am treated justly regarding mobile phone base stations.	.68
V10 Concerning mobile phone base stations, I believe there is a need for more fairness. (R)	.84
Fear; $\alpha = .83$	
V11 When I think of mobile phone base stations, I get a fearful gut feeling.[a]	.88
V12 I think everyone is somewhat afraid of mobile phone base stations.	.44
V13 When I see a mobile phone base station, I become scared.	.86
V14 I feel afraid when I think of mobile phone base stations.	.80
Anger; $\alpha = .90$	
V15 I feel angry when a new mobile phone base station will be constructed.[a]	.83
V16 I cannot understand why some people get angry about mobile phone base stations. (R)	.41
V17 I easily get angry when I discuss mobile phone base stations with other people.	.59
V18 When I see all these mobile phone base stations, I get angry.	.79
V19 I get annoyed when I hear that a new mobile phone base station will be constructed.	.91
V20 I am often annoyed about the fact that mobile phone base stations are almost everywhere.	.86
V21 If someone believes that all the mobile phone base stations are necessary, I get annoyed.	.76
V22 I cannot imagine why I should feel annoyed about mobile phone base stations. (R)	.72

Table 4.1. *(cont.)*

Factors and variables	Factor loadings (*a*)
Acceptance; $\alpha = .83$	
V23 I would not file an objection against a base station of a mobile phone company in my neighborhood.[a]	.71
V24 Mobile phone communication is not possible without base stations; therefore, people should accept mobile phone base stations in their neighborhoods.	.79
V25 I would accept a base station from a mobile phone company in my neighborhood.	.85
V26 People should not fight against base stations from mobile phone companies in their neighborhoods.	.61
Benefit Perception	
V27 How beneficial do you consider mobile phone base stations to be for Swiss society as a whole?	
Risk Perception	
V28 How risky do you consider mobile phone base stations to be for Swiss society as a whole?	

Note. Error correlations between V5 and V6, and between V7 and V9 were added in the course of model modification.

[a] Fixed parameter for statistical identification.

R = reverse scored.

3. Results

The hypothesized model yielded a reasonable fit (Hu & Bentler, 1995) to the data (CFI = .90; RMSEA = .075). However, the modification indices indicated that the addition of a correlation between the error terms for items V5 and V6 would improve the model fit. Relaxing the parameter seems to be justified due to the content of the items: Items V5 and V6 were related to the perceived control of a base station's construction, whereas all the other items of the same scale measured the perceived control of the base station's radiation. Table 4.2. shows the chi-square distribution (χ^2) for the revised model, in which the correlation between the two error terms has been incorporated. The χ^2 decreased significantly (χ^2 (1) = 166.3, p < .001). The modification indices also suggested the addition of a correlation between the error terms for items V7 and V9. Correlation between these two items is likely because both items were written from a personal point of view; thus, they were more subjective than the other items. As shown in Table 4.2., estimation of this revised model yielded a significant decrease in the χ^2 statistic (χ^2 (1) = 79.2, p < .001). Inspection of the modification indices further showed that adding a covariance between the latent variables fear and anger would contribute to an improved model fit. As indicated in Table 4.2., χ^2 decreased significantly in the new model (χ^2 (1) = 90.8, p < .001).

Table 4.2. Test Statistics for the Hypothesized Model

Model	χ^2	*df*	CFI	RMSEA	$\Delta\chi^2$	*Δdf*
Initial	1299.9	340	.90	.075		
Addition of correlations among error terms e(V7), e(V8)	1133.6	339	.91	.069	166.3	1
Addition of correlations among error terms e(V9), e(V11)	1054.4	338	.92	.065	79.2	1
Addition of path fear ↔ anger	963.6	337	.93	.061	90.8	1

Note. CFI = comparative fit index; RMSEA = root mean square error of approximation.

The final model showed an acceptable to good fit. Standardized factor loadings for the final model are presented in Table 4.1.. Most of the specified relationships were highly significant (p < .001 or p < .01). However, the relationships between risk perception and acceptance, between fear and acceptance, and between fear and benefit perception were not significant (p > .05). The model accounted for a substantial amount of variation in fear (60%) and anger (67%). The model also explained 27% and 26% of the variance in risk and benefit perception, respectively. Furthermore, the model accounted for 63% of the variance in acceptance. Figure 4.2. presents the final model schematically.

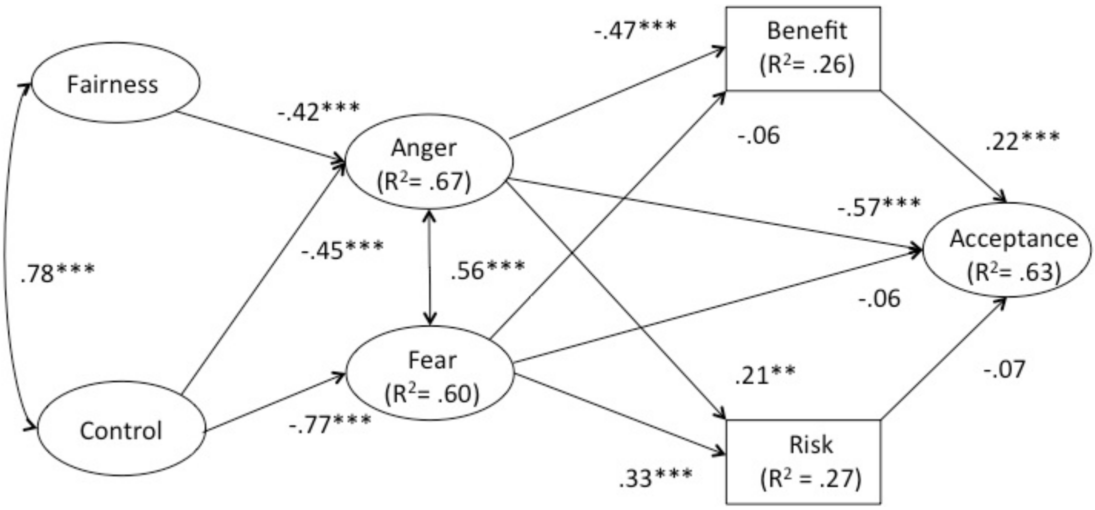

Figure 4.2. Final model of determinants of acceptance of mobile phone base stations. Values represent standardized estimates, *N* = 500. Asterisks refer to levels of significane: ** p < .01; *** p < .001

4. Discussion

The aim of our study was to examine not only how specific emotions determine risk judgments but also how emotions develop in a risk context. Our research question was detached from global affect as considered in the affect heuristic, since a focus on global affect may not suffice to thoroughly comprehend decision making (Zeelenberg et al., 2008). We concentrated on fear and anger as they have been identified as particularly important in risk perception (Lerner & Keltner, 2001; Peters et al., 2004; Sjöberg, 2007).

Structural equation modeling was used to test these relationships. Data analysis demonstrated that the model shown in Figure 4.2. fits the data quite well. Results of the structural equation model indicate that anger strongly determined the acceptance of mobile phone base stations, and had a strong impact on benefit perception. Fear, on the other hand, had no influence on acceptance and benefit perception but strongly influenced risk perception of mobile phone base stations. Risk perception was also determined by anger, but to a lesser extent.

These results show that different emotions can have different influences on risk perception and acceptance of hazards, which is in line with the work of Sjöberg (2007), who observed that anger most strongly predicted acceptance of a risk. The findings are also in accordance with the feeling-is-for-doing approach (Zeelenberg et al., 2008), because they highlight that an emotion-specific approach allows for more specific predictions in a risk context.

In the present research, we examined emotions integral to the object being judged. Thus, this study differs from other studies that focus on the carryover effects of incidental emotions (e.g., Lerner & Keltner, 2001). As noted by Zeelenberg and colleagues (2008), incidental emotions are rather irrelevant for a current decision and give only little insight into the functional influence of emotions in regular decision making. Integral emotions, in contrast, serve as a signal to the decision maker and work in service of goal pursuit. Similarly, Frijda (1986) suggested that most emotions are action tendencies, i.e., a state of readiness to execute a given kind of action. Accordingly, the two emotions examined in the present study, fear and anger, should lead to different tendencies to execute expressive behavior. Frijda (1986) suggested that anger is accompanied by intentionality, or the idea of an external agent. Thus, it makes sense that anger primarily influences the acceptance of a mobile phone base station, because the construction of a base station is more closely and directly related to external persons than the risks related to it. Fear, in contrast, is reflected in behavior such as escape from a threat (Frijda, 1986), which might explain why fear primarily determined whether a risk was perceived as high or low. Likewise, studies relating to the psychometric paradigm have shown that dread—which is more closely related to fear than to anger—is a major determinant of risk perception.

We found no relationship between fear and benefit perceptions. Other studies have shown that mere affect strongly determines both risk and benefit perceptions. With the results of the present study, one could argue that this effect is due to different emotions. Anger primarily determined benefit perceptions, while fear influenced risk perceptions. This difference might be covert in studies that consider affect in more general terms.

An emotion-specific approach can also be useful for identifying how affective reactions toward risks emerge. Our model indicates that control is an important antecedent for fear and anger. Fear was strongly determined by control, and anger was influenced by both control and fairness. These results suggest that people’s fears and anger regarding mobile phone base stations would be reduced if people could control the radiation or the construction of a base station. Since fairness and control were strongly related in our model, this aim could also be achieved when fairness is increased. Involving the public in the decision-making processes would be one possibility for increasing fairness. A study by Dohle and colleagues (Dohle, Keller, & Siegrist, 2010a) has shown that people strongly favor the idea that representatives from the public should be allowed to participate in base station siting decisions. In a similar vein, Sandman (1987) pointed out that fairness reduces public outrage and, thus, decreases anger. Likewise, fear might be decreased if people have a feeling of control over exposure to radiation from a base station. Providing concerned citizens with exposimeters that display personal radiofrequency electromagnetic field exposure or integrating a scale on mobile phones that displays exposure in relation to international exposure limits could be a way to visualize radiation and thus to technically implement perceived control.

The present results are not limited to mobile communication; they can also be applied to other risks. Risks from mobile communication are rather overestimated: although there is little evidence the exposure leads to severe health consequences, many people are quite alarmed about its consequences. However, other hazards such as radon, smoking, or talking to someone on the phone while driving are risks that are perceived with indifference. For risk communication purposes, our model suggests that highlighting the loss of control (for example, by emphasizing that phoning while driving has similar effects on reaction times as driving while intoxicated) might be helpful to increase fears in underestimated risks, which in turn might lead to a higher risk perception.

We found a relationship between benefit perceptions and acceptance but no relationship between risk perception and acceptance. A number of studies have shown that acceptance is more strongly influenced by benefit perceptions than risk perceptions (e.g., Siegrist, 2000). Our finding might also be due to methodological factors: the item on acceptance was expressed from a personal point of view, while the items on risk and benefit perception asked about Swiss society as a whole. Furthermore, risk and benefit perceptions were measured using a single item. Single items usually explain less variance than Likert scales and tend to have low reliabilities. As a result, we may have underestimated the effects of risk and benefit perception on the acceptance of mobile phone base stations. Moreover, it should be noted that, in addition to control and fairness, there might be other cognitive appraisals in the context of fear and anger that were not taken into consideration. However, because we were primarily interested in consequences for risk communication, we focused on appraisals that are modifiable in a risk context. Similarly, it might be possible that, for other risks (especially for those that are rather underestimated), positive emotions and their corresponding appraisals are as important as negative ones. Furthermore, it would be useful to extend the present research to an experimental setting. Future studies might want to investigate how manipulations of controllability and fairness act on emotions and judgments of risks, benefits, and acceptance.

In the present study, we called into question whether studying broad and unspecific affective reactions suffice to understand decision making, especially in a risk context. Linking the affect heuristic with appraisal theories, one could argue that mere affect serves as the first appraisal when facing a hazard. It has been noted that virtually all appraisal theorists hold that in the first step people start with an evaluation of whether or not the stimulus is good or bad for them (Barrett, Ochsner, & Gross, 2007). However, since human beings are provided with a multifaceted emotional life, we believe that persons do not stop at this point but rather proceed with taking up other, more complex appraisals such as controllability or fairness. To truly understand the influence of affect on decision making, it is important to investigate these diverse appraisals and the specific emotions that arise from the appraisals.

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Chapter V

Conjoint Measurement of Base Station Siting Preferences

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Manuscript accepted for publication as: Dohle, S., Keller, C., & Siegrist, M. (2010). Conjoint measurement of base station siting preferences. *Human and Ecological Risk Assessment, 16, 1–12.*

Abstract

Mobile communication has become a ubiquitous part of today's life. The ongoing growth of this technology, however, involves the construction of new mobile phone base stations in order to assure network coverage. The selection of a new base station site often results in conflicts between providers and public authorities, on the one hand, and residents on the other. The aim of the present study was to examine public preferences regarding base station sites. A random sample of 503 persons from the German speaking part of Switzerland was interviewed face-to-face in their homes. Conjoint analysis was used to evaluate participants' preferences for various attributes of base stations (appearance, location, building, decision process). The results show that location plays the most important role in participants' acceptance of base stations. The findings also indicate that most people would prefer a covered or camouflaged base station to a freely visible one. By means of a cluster analysis, several segments were distinguished, showing that base station siting preferences were not homogeneous. Implications for risk communication are discussed.

1. Introduction

Over the last decade, mobile communication has become a global phenomenon. Launched in Finland in 1991, mobile services increased to four billion mobile connections worldwide (ITU, 2009). However, the ongoing growth of mobile communication and other technologies (Hilty, Som, & Kohler, 2004) also gives rise to public concerns about potential health effects regarding electromagnetic fields (EMF). In particular, some citizens fear that mobile phone base stations may lead to severe health disorders, and strongly support corrective measures such as warning labels, appliance shielding and further research (MacGregor, Slovic, & Morgan, 1994).

From a technical point of view, in order to ensure network coverage, it is necessary to construct mobile phone base stations in the vicinity of places where people want to use their phones. The transmission power of base stations constructed outside of living areas is often not sufficient to ensure stable mobile reception; besides, the radiation from the mobile phone of a phoning person would be at a maximum. Thus, centrally located base stations reduce the mobile phone user’s daily radiation exposure, because mobile phones and mobile phone base stations are connected entities: they radiate less when the distance between them decreases (Cousin & Siegrist, 2010). Furthermore, because of the narrow vertical spread of the base station’s beam, the levels of exposure inside or to the sides of buildings with base stations mounted on their rooftops are normally very low (WHO, 2000).

In order to reduce public fears about EMF and to promote greater acceptance of a new facility, various courses of action have been suggested (Wiedemann & Schütz, 2005). Among others, public participation in base station siting decisions is frequently mentioned by public authorities (e.g., WHO, 2000). Little is known, however, about public preferences regarding mobile base station sites. It is unclear which characteristics of base stations are deemed most important by the public and whether there are considerable differences among segments of the population regarding site preferences. By means of a conjoint analysis, the present study is designed to address these issues in more detail.

1.1. Conjoint Analysis and Risk Perception

Conjoint analysis is a decompositional method developed to investigate preferences for hypothetical or real products and services. Respondents evaluate or rank a set of total profile descriptions and consider different attributes jointly, in contrast to compositional approaches, where various attributes are assessed separately (Green & Srinivasan, 1978).

The biggest advantage of conjoint analysis is that it maintains a high degree of realism and resembles real choice situations (Hair, Anderson, Tatham, & Black, 1998). It is based on the assumption that it is easier for people to judge a product or service in its global utility than to assess each attribute in isolation. In addition, conjoint analysis is also useful in identifying different groups of respondents with similar preferences (Hair et al., 1998). These segments, usually derived using cluster analysis, can then be connected to various descriptor variables, such as socio-demographic or psychological variables. Despite its widespread use in other disciplines, especially in market research, only few studies used conjoint analysis to investigate risk assessment or environmental issues (Bond, 2001; Gegax & Stanley, 1997; Machado & Mourato, 2002; McLean & Mundy, 1998; Winslott Hiselius, 2005). Winslott Hiselius (2005) investigated preferences for the transport of hazardous materials using a choice experiment, a variant of traditional conjoint analysis. In a similar vein, Machado and Mourato (2002) studied marine water quality improvements and health risk reductions. Choice experiments, however, do not allow for individual level analyses (Louviere, 1991). To the best of our knowledge, no study has examined EMF risks using traditional conjoint analysis.

1.2. Identification of Relevant Attributes for Siting Decisions

For the design of a conjoint analysis, researchers should ensure that the attributes and attribute levels are both communicable and actionable (Hair et al., 1998). Beside these general characteristics, theoretical considerations on the identification of attributes should also be taken into account.

Several outcome variables (i.e. physical and tangible base station characteristics) may play a crucial role in base station siting preferences. First, the location of the base station might be a key issue, since research indicates that lay people often prefer great distance between themselves and the base station (Cousin & Siegrist, 2010). Secondly, the appearance of the base station seems to be an important aspect as well. A study using a free association technique carried out by Siegrist et al. (2005) suggests that lay people frequently mention aesthetic aspects when they think of mobile phone base stations. Changing the appearance of the base station, however, can be realized either by hiding the base station (behind sheeting etc.), or by camouflaging the base station (for example, as a tree or a crucifix). The latter option, in particular, might be perceived very differently because some might see a camouflaged base station as an aesthetic improvement, while others sense it as an attempt to deceive the public. Finally, a third outcome variable relevant for people's acceptance of base stations might be the type of building (WHO, 2000). Residents often object to base stations in the vicinity of sensitive zones (e.g kindergartens, schools or dwellings), although these sites would ensure minor exposure for the mobile phone users. Accordingly, placing a base station on a church might be perceived as inappropriate, or even as impious, by some people.

Besides these outcome variables, the process of the decision should also be taken into account. The question arises of whether people would rather reject or accept the idea that representatives from the public be allowed to participate in base station siting decisions. Several researchers have argued that one of the key features in environmental risk perception is fairness (Renn, Webler, & Wiedemann, 1995). Procedural fairness means that each person has the opportunity to express individual interests and can contribute to the collective will (Linnerrooth-Bayer, 1995). However, some residents might also conclude that pubic representatives lack the knowledge to find appropriate sites, and thus reject this option.

1.3. The Present Study

Conjoint analysis is a fairly new approach in the field of environmental evaluation and permits a systematic understanding of preference structures. It has been suggested that it might be a useful tool for environmental risk analysis and communication (Alriksson & Oberg, 2008).

After reviewing the relevant literature, we identified four key attributes to be crucial for base station siting decisions, i.e. the location, the appearance, the type of building and the decision process itself. The purpose of the present work is to determine the relative importance of these attributes from the perspective of laypeople, and thus to explore which aspects of base station sites are considered most important by the public.

A second aim of the study is to detect specific segments of respondents that differ in their preferences. Some researchers have emphasized that individual differences in risk perception are often neglected (Siegrist, Keller, & Kiers, 2005). Moreover, we wanted to examine if these groups of respondents would also differ in respect to other characteristics that were found to be important in the risk perception of mobile communication, such as trust

(Poortinga & Pidgeon, 2003; Siegrist, Gutscher, & Earle, 2005), knowledge (Cousin & Siegrist, 2010), and health beliefs (Cousin & Siegrist, 2008).

2. Method

2.1. Participants

The data were collected in a survey conducted in the urban area of Zurich, Switzerland. A sample of 503 participants aged from 18 to 80 was interviewed face-to-face in their homes between November, 2008, and March, 2009.

Participants were randomly selected from the electronic telephone directory. They were first contacted by mail and informed about the study. Approximately one week later, they were called by an interviewer and asked to participate in the study. The complete face-to-face interview lasted one hour on average. The response rate was about 35%[1]. Interviewers were trained to conduct the interview in a standardized manner.

Forty-five percent (*n* = 225) of the respondents were female, and 55 % (*n* = 275) were male. The mean age was 51.60 (*SD* = 15.10). Self-reported education level ranged from primary or lower secondary school (6%; *n* = 28), upper secondary vocational school or upper secondary university preparation school (59%; *n* = 294), to college or university (36%; *n* = 178). According to census data (BFS, 2009), males were slightly overrepresented. Moreover, age and education level were slightly higher than the Swiss average. Ninety-four percent of the participants (*n* = 470) owned a mobile phone. On average, participants indicated that they use their mobile phone 26.04 (SD = 60.76) times per week for communication purposes. Three participants refrained from filling out the questionnaire that was presented at the end of the interview; thus, no demographic data were available for them.

[1] The response rate was calculated as: “Response rate” = (“number of completed interviews”)/(“number in sample-number not eligible”).

2.2. Conjoint Analysis

In the conjoint analysis[2], hypothetical mobile phone base station sites were presented to the participants. The four attributes and their corresponding levels were: location (outside of the village/ on the outskirts/ in the center of village), appearance (visible/ covered/ camouflaged), building (factory/ church/ dwelling) and the decision process about the location of the base station site (residents were involved/ government was involved/ only provider decided).

Location	center of village
Appearance	covered
Bulding	dwelling
Decision Process	residents were involved in site selection

Figure 5.1. Sample stimulus card.

Given that four attributes with three levels would yield 81 (3 x 3 x 3 x 3) possible combinations, it was necessary to reduce the number of the stimulus cards (i.e., the hypothetical mobile phone base station sites) by means of a fractional factorial design. The design and the number of the stimulus cards, which were presented in full-profiles, was determined through the ORTHPLAN procedure of the statistical software SPSS. The interviewers explained the meaning of the card attributes beforehand by means of an illustration that showed some additional explanations about the attributes. For example, the illustration showed three pictures of a mobile phone base station that was freely visible, covered with sheeting, or camouflaged as a crucifix. The specific attributes of the different sites were listed in table form and printed on cards (Figure 5.1. shows an example stimulus card). The participants were asked to rank the cards according to their preference.

2.3. Questionnaire

The questionnaire was designed to measure a broad range of constructs that were related to mobile communication. For the present study, variables measuring the following

[2] Previous to the conjoint analysis, participants conducted a free association task and a Single Category Implicit Association Task; results of these tasks are not reported here.

five constructs were used: risk perception, benefit perception, knowledge, health beliefs, and trust.

Risk and benefit perception of mobile phone base stations was measured using the item: “How risky (beneficial) do you consider mobile phone base stations to be, for the Swiss society as a whole?”. Participants responded on a 6-point scale ranging from 1 (“small”) to 6 (“large”).

The knowledge questions about mobile communication were taken from a scale developed by Cousin and Siegrist (2010). The original scale is divided into several domains. For the present study, the subscales “base stations” and “interaction patterns” were selected. The eleven items (e.g., “A base station gives off the same level of radiation throughout the whole day”) could be answered using the options “true”, wrong”, or “don’t know”. A summative index of the correct items was calculated for further analysis. In our sample, the mean of the scale was 3.40 (*SD* = 2.48), indicating that participants had little knowledge about mobile communication (only one person was right on all of the eleven items).

Health beliefs were assessed by means of a scale introduced by Cousin and Siegrist (2008). The sixteen questions (e.g., “There are some people who can feel even low levels of radiation”) could be answered using the options “true”, wrong”, or “don’t know”, and were summarized to a scale. High values on the health belief scale indicate a strong belief in adverse health effects of mobile communication. On average, participant agreed on 7.25 (*SD* = 3.40) items.

Finally, trust in mobile communication authorities was measured by asking participants to evaluate how much they trusted several authorities and their specific sphere of authority. They indicated their trust in (a) providers (technical aspects), (b) providers (health aspects), (c) federal authorities (legal framework), (d) federal authorities (health care), (e) research groups at universities (research), and (f) consumer protection boards (consumer safety). Participants answered these questions on a 6-point-scale ranging from 1 (“no trust”) and 6 (“complete trust”). For the final trust scale, a mean score of all items was calculated. The reliability of the scale was checked by calculating Cronbach’s alpha (α = .66). Participants trusted research groups at universities most (*M* = 4.68, *SD* = 1.01), and providers (both items) least (*M* = 3.01, *SD* = 1.09).

3. Results

3.1. Part-Worths and Relative Importance of Attributes

Based on the respondents' ranking, part-worth utilities for each individual respondent and for the total sample were calculated (using SPSS CONJOINT). Part-worth utilities provide a quantitative measure of the preference for each attribute level (SPSS, 2007). They were estimated using Ordinary Least Square (OLS) regression analysis and used to determine the relative importance values of each attribute. Importance values are calculated by taking the part-worth utility range for each factor separately and dividing it by the sum of the utility ranges for all factors. Thus, they provide a measure of how important the factor is to overall preference (SPSS, 2007).

The attribute of greatest importance was the location of the mobile phone base station (35%). Decision process and building were of almost equal importance (24% and 23%, respectively), and the appearance of the base station had the lowest importance (17%). Thus, location was twice as important as appearance.

Figure 5.2. shows the part-worth utility scores for each attribute. The results clearly showed positive utility for a location outside of the village; a location on the outskirts had only a slightly positive utility. In contrast, locations in the center of the village yielded a negative utility.

Furthermore, the appearance of the mobile phone base station had a positive utility when it was covered or camouflaged. When the base station was visible, appearance resulted in a negative utility. Concerning the building, results demonstrate that participants preferred a mobile phone base station that was constructed on a factory, but they rejected a base station that was mounted on a dwelling. With regard to the decision process, Figure 5.2. indicates a positive utility for a decision where residents were involved. Also, a decision process in which the government was involved had a positive utility, while a decision process where only the provider decided about the location of the base station clearly yielded a negative utility.

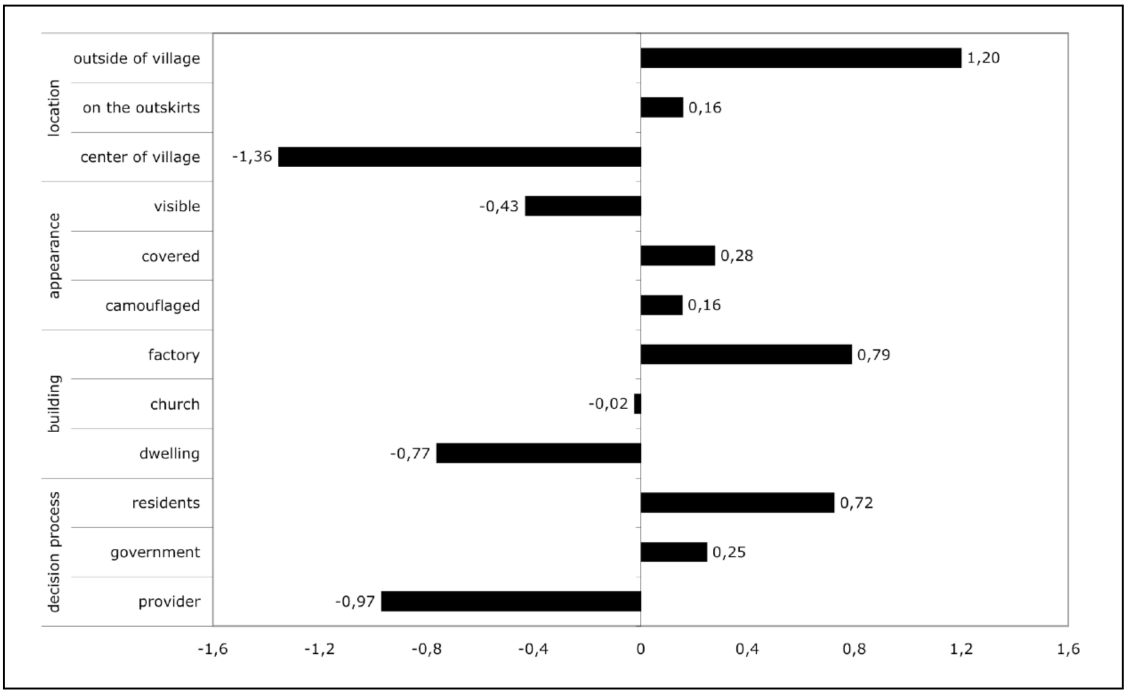

Figure 5.2. Part-worth utilities for each attribute level (all respondents).

3.2. Segmentation

Cluster analysis was applied to classify participants into homogeneous subgroups. A K-Means clustering based on the individual part-worth utilities was used. A four-cluster solution showed high substantial interpretability, and clusters differed significantly on all variables used for clustering. Table 5.1. shows the results of the cluster analysis, together with the size of each cluster.

To describe the clusters, one-way analysis of variance (ANOVA) and Tukey-HSD post-hoc analyses were applied for the continuous variables (risk perception, benefit perception, knowledge, health beliefs, trust and age). The results are presented in Table 5.2. Age did not reach significance and is therefore not presented in the table ($p > .28$). For the discrete variables (gender and education), a chi-square test was performed. Gender (χ =8.06, $p = .045$), but not education ($p > .20$), was a significant descriptor for the four segments.

The findings indicate that participants in cluster 1 (11%) place great importance on the type of building on which the base station is constructed. They would not accept a mobile phone base station on a church, and prefer that it be built on a factory. Cluster 1 is the smallest segment. It is the only segment that favors base stations that are freely visible and refuses camouflaged base stations. In contrast to cluster 2, it has less knowledge about mobile communication. Participants in cluster 2 (15%) mainly attach importance to the appearance of the base station. They reject freely visible base stations and rather prefer one that is camouflaged or covered. Cluster 2 is the only group that prefers a base station that is located in the center of the village, which would be the best location from a public health perspective (Cousin & Siegrist, 2010; WHO, 2000). Location, however, was not of high importance. Compared to the other groups, participants of cluster 2 perceive lower risks and higher benefits from mobile communication, have more knowledge, fewer health beliefs and have more trust in mobile communication authorities. Participants of cluster 2 are predominantly male (70%).

Table 5.1. Utility of Each Attribute Level, and Importance of the Attributes “Location,” “Appearance,” “Building,” and “Decision Process” in Groups Obtained Through Cluster Analysis

	Cluster 1 (*n* = 54)	Cluster 2 (*n* = 73)	Cluster 3 (*n* = 167)	Cluster 4 (*n* = 209)	*F*	*p*
Utility of location “outside of village”	.77	-.47	.54	2.42	266.27	.000
Utility of location “on the outskirts”	-.25	.17	.07	.33	10.41	.000
Utility of location “center of village”	-.52	.30	-.60	-2.75	416.74	.000
Utility of appearance “visible”	.20	-2.15	-.11	-.25	124.84	.000
Utility of appearance “covered”	.17	.89	.16	.18	19.69	.000
Utility of appearance “camouflaged”	-.37	1.26	-.05	.07	62.27	.000
Utility of building “factory”	1.57	.65	.89	.56	19.00	.000
Utility of building “church”	-1.91	-.16	.44	.14	121.37	.000
Utility of building “dwelling”	.34	-.49	-1.32	-.70	41.41	.000
Utility of decision process “residents”	.27	-.05	1.54	.46	71.65	.000
Utility of decision process “government”	-.05	.51	.58	-.03	25.59	.000
Utility of decision process “provider”	-.22	-.45	-2.12	-.43	156.92	.000
Importance of location	20.57	21.14	17.51	57.30		
Importance of appearance	20.58	39.47	13.81	12.01		
Importance of building	41.08	18.90	27.87	16.84		
Importance of decision process	17.77	20.50	40.81	13.86		

Table 5.2. Means (With Standard Deviations in Parentheses) of Group Characteristics and Statistical Differences Obtained via Analysis of Variance

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	F	p
Risk Perception	3.59 (1.35)^{b}	2.79 (1.03)^{a}	3.58 (1.23)^{b}	3.63 (1.22)^{b}	5.46	.001
Benefit Perception	4.11 (1.46)^{a}	4.95 (1.15)^{b}	4.10 (1.21)^{a}	4.17 (1.12)^{a}	9.331	.000
Knowledge	3.15 (2.65)^{a}	4.18 (2.90)^{b}	3.36 (2.48)^{a,b}	3.20 (2.23)^{a}	3.07	.028
Health Beliefs	6.94 (3.72)^{b}	5.53 (2.55)^{a}	7.67 (3.49)^{b}	7.60 (3.34)^{b}	8.28	.000
Trust	3.94 (0.77)^{a,b}	4.05 (0.74)^{b}	3.72 (0.68)^{a}	3.76 (0.78)^{a}	4.15	.006

Note. ^{a,b} Different letters in a row indicate statistical difference, according to Tukey HSD post hoc analysis ($p < 0.05$).

Participants belonging to cluster 3 (33%) are mainly interested in the decision process. A decision process in which only the provider is included is clearly rejected. Rather, they would prefer that residents are involved in the decision process. Some importance is also attached to the attribute “building”. Like all other segments, they prefer a base station that is mounted on a factory. They share with clusters 1 and 4 that they see higher risks and lesser benefits of mobile communication.

Cluster 4 is the largest cluster (42%). Participants of this segment stress the importance of the location, and hardly take other attributes into account. They strongly favor a base station that is located outside the village and refuse base stations located in the center. Like cluster 3, they have little trust in mobile communication authorities. Compared to cluster 2, they also have less knowledge.

4. Discussion

The findings of this study give insight to public preferences for mobile phone base station sites. Results show that a covered base station that is mounted on a factory, and whose remote location is determined by residents, had the highest utility.

Location of the base station plays the most critical role in acceptance of base station sites. Participants clearly prefer base stations outside of the village, which is in line with Cousin and Siegrist (2010), who showed that people favor locations that are located as distant as possible.

Less importance is placed on the decision process. However, the findings indicate that respondents do not value decisions in which only the provider determines the location, probably because providers are perceived as less trustworthy than governmental institutions. Other researchers have suggested that fairness plays an important role for residents (Earle & Siegrist, 2008; Renn et al., 1995), which is reflected in the fact that participants appreciate decisions where residents are involved.

The attribute “building” was equally important as the decision process. Factories are clearly favored as appropriate buildings for base stations. Presumably, participants have drawn the conclusion that workers in a factory would only be exposed during the day, while residents of a dwelling would also be exposed at nighttime. Also, participants may believe that factory workers are at risk anyway, and that the radiation exposure would only marginally contribute to the total risk of a factory worker.

Appearance was the least important attribute, only half as important as the location of the facility. According to WHO recommendations (WHO, 2000), aesthetic aspects should be taken into account in siting base stations. In fact, our results show that visible base stations are rejected by most participants. Furthermore, for a small portion of participants (cluster 1), aesthetic modifications that aim at camouflaging base stations are clearly rejected, probably because participants fear that camouflaged base stations are deliberately intended to delude residents. Nonetheless, all respondents showed a positive utility for covered base stations. Consequently, if aesthetic modifications of mobile phone base stations are intended (WHO, 2000), covering base stations (with sheeting etc.) would reach the broadest consensus among the population.

The cluster analysis identified four segments with different preferences, indicating that the sample was not homogeneous in their siting preferences. Cluster 2 differed from the other clusters in regard to their preferences and also with respect to several descriptor variables. To minimize radiation for the mobile phone user, it is reasonable to place base stations at a central village location, and cluster 2 was the only cluster that favored this site. Compared to other respondents, they were characterized not only by little risk and higher benefit perception, higher trust, and fewer health beliefs, but also by more knowledge. This is in line with Cousin and Siegrist (2010), who demonstrated that knowledge gaps were related to respondents' preferences regarding base station siting. For example, using a forced- choice task, they could show that respondents with little knowledge about interaction patterns between mobile phones and base stations preferred locations, which would cause more exposure for the phoning population.

Following this line of argument, our research provides a guide for risk communication regarding EMF. At first, it highlights the importance of knowledge transfer. Our findings confirm that people generally have little knowledge about the functionality of mobile phone base stations and the interaction pattern of mobile phones and base stations, which emphasizes that provision of information should focus on imparting these facts. Secondly, because we found that people who select advantageous sites also have less negative health beliefs, the results highlight that it is advisable for public health authorities to communicate as clearly as possible about the functionality and health effects of mobile communication in order to reduce ambiguities. Third, our findings also show that trust is crucial for risk communication, since it was found to be a significant descriptor for the clusters. In order to foster trust, communication programs designed by public institutions may, for example, facilitate a two-way communication process in which citizens have the possibility of expressing their needs (as suggested by Renn & Levine, 1991).

The present study was aimed at exploring the siting preferences of a randomly selected sample from the general population. Results are therefore limited to participants, who were presumably moderately involved in the topic. For this reason, results of the conjoint analysis might be different for residents who are directly affected by a real base station conflict in their neighborhood, because highly involved participants may weight the attributes and attribute levels differently. Moreover, only the most important attributes of a base station could be addressed in the present study. From a theoretical point of view, it would have been possible to further subdivide some of the attribute levels. The appearance of a freely visible base stations, for example, could be broken down into height, style, color etc. Increasing the number of attribute levels, however, would also lead to a higher number of stimulus cards, and sorting too many cards might overstrain participants.

A conjoint analysis as employed in the present study is thought to be instrumental for further investigation of public preferences for mobile base station sites. Since the findings of our study underscore, among others, the importance of knowledge for choosing adequate locations, it might be interesting to incorporate conjoint analysis in an experimental setting. An experiment may shed more light into the question of how much and what kind of knowledge is needed in order to enable citizens to come to appropriate base station site decisions. Such an experiment could be combined with a thought listing technique (Brock, 1967; Greenwald, 1968), in which participants are asked to list everything about which he or she was thinking during the ranking of the conjoint cards. This technique may give insights about the reasons why one option is preferred over the other, which remains speculative in traditional conjoint analysis.

Finally, we believe that the implementation of more realistic measures such as conjoint analysis in risk perception must not be restrained exclusively to an EMF topic. Conjoint analysis was found to be a useful tool when applied to mobile phone base stations preferences, but it may also be applied to preferences regarding, for example, power plant sites, waste incineration plants and other environmental risks. Beyond this, the segmentation of participants into homogeneous subgroups permits the tailoring of information material to the specific characteristics of those groups. Thus, especially in combination with other techniques such as cluster analysis or experimental methods, we conclude that conjoint analysis allows for an improved understanding of environmental risk perception and communication.

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Chapter VI

The Impact of Specific Information Provision on Base Station Siting Preferences

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Manuscript submitted for publication as: Cousin, M.-E., Dohle, S., & Siegrist, M. (2010). The impact of specific information provision on base station siting preferences.

Abstract

When it comes to the new siting of a mobile communication base station in one's neighborhood, some people react with rejection because they fear health consequences from the emitted high-frequency radiation. Most people would prefer to site base stations outside residential areas, but from a public health perspective, this may result in even more radiation for the phoning population. Therefore, authorities are interested in improving the current base station siting processes. The question arises whether specific knowledge enhancement would influence base station siting preferences or whether affective or emotional components (due to the scientific uncertainties involved) would overrule the influence of such attempts. To answer this question, an experimental study with a convenience sample of Swiss citizens (N = 228) was conducted. Participants were confronted with one of three texts: a neutral text (control group), an information booklet about mobile communication and an emotionally charged newspaper article that reported a conflict about the siting of a new base station. After reading the text, participants filled out a questionnaire about their perception of mobile communication and their base station siting preferences. Reading the information booklet increased participants' knowledge and led to perceptual changes of base stations and mobile phones. Importantly, participants reading the booklet were able to transfer their knowledge to a base station siting task and found locations that would emit less radiation for the phoning population. Implications and limitations of these results are discussed.

1. Introduction

Mobile communication is part of daily life and provides many benefits. In many western countries, vast majorities of the population own a mobile phone (International Telecommunication Union [ITU], 2009). To make wireless telecommunication possible, an infrastructure consisting of base stations (= mobile communication antennas or transmission masts) is needed. This infrastructure is perceived with suspicion especially in residential areas. Some people fear that the emitted high-frequency electromagnetic fields (EMF) may harm their health or wellbeing (Burgess, 2002, 2004; European Commission [EC], 2007). Therefore, they would prefer to locate base stations outside of residential areas, the farther away the better (Dohle, Keller, & Siegrist, 2010a).

Mobile communication and its consequences have initiated various research activities. In addition to the extensive research concerning the potential health effects, societal aspects such as the handling of scientific uncertainties and adequate precautionary measures (e.g., Barnett, Timotijevic, Vassallo, & Shepherd, 2008; Dolan & Rowley, 2009), risk communication of scientific uncertainty (e.g., Barnett, Timotijevic, Shepherd, & Senior, 2007; Timotijevic & Barnett, 2006), participatory approaches for base station siting (e.g., Wiedemann & Schütz, 2008) and the relevance of trust in regulation (e.g., Poortinga & Pidgeon, 2003; Siegrist, Earle, & Gutscher, 2003) have been investigated. To the best of our knowledge, past studies have not examined whether specific knowledge about mobile communication influences people's preferences in base station sitings. People may be concerned about having a base station in their backyard, because they rely on flawed mental models.

When the base station is far away or the connection is bad, the mobile phone is forced to radiate more in order to reach the nearest base station (Independent Expert Group on Mobile Phones [IEGMP], 2000; Neubauer et al., 2005). Therefore, an infrastructure with many low-powered antennas in areas where people are actually using their mobile phones may minimize the exposure of mobile phone users (GSM networks). The interrelations between mobile phones and base stations are somewhat counterintuitive. A certain amount of specific knowledge is needed for understanding them.

The present paper explores whether specific knowledge provision about the technical functionality of mobile communication influences people's perception of mobile communication and their base station siting preferences.

1.1. People's Perception and Knowledge of Mobile Communication

Scientific evidence provides little support for adverse health effects of high-frequency radiation emitted by mobile communication at levels below the current international standards (International Commission on Non-Ionizing Radiation Protection [ICNIRP], 1998; Valberg, van Deventer, & Repacholi, 2007; World Health Organization [WHO], 2002). However, long-term studies are lacking. Therefore, there are scientific uncertainties concerning the potential health effects of long-run exposure.

Several studies have surveyed laypeople's perception of EMF emitted by mobile communication. These studies found, compared to other environmental or health risks, moderate concerns (e.g. EC, 2007) but also the perception that base stations are more dreadful or risky than mobile phones (Bronfman & Cifuentes, 2003; Hutter, Moshammer, Wallner, & Kundi, 2004; Siegrist, Earle, Gutscher, & Keller, 2005; Siegrist, Keller, & Cousin, 2006; EC, 2007; Ruddat, Sautter, Renn, & Pfenning, & Ulmer, 2010). Other studies explored affect associated with mobile communication (e.g., Dohle, Keller, & Siegrist, 2010b, 2010c). A reaction time-based study conducted by Dohle and colleagues (2010b) showed that some people, such as EMF experts, immediately attach positive concepts to mobile phone base stations, while other people, such as base station opponents, react negatively towards base stations. In addition, specific emotions such as fear and anger have a different influence on judgments in regard to mobile communication: Risk perception of mobile phone base stations is more strongly influenced by fear of base stations than by anger; on the other hand, benefit perceptions and the acceptance of mobile phone base stations are primarily determined by anger reactions regarding base stations (Dohle et al., 2010c). Taken together, these results suggest that people rely on the affect heuristic (Alhakami & Slovic, 1994; Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic, Finucane, Peters, & MacGregor, 2002, 2004) when they judge mobile communication risks. Dohle et al.'s (2010b) results also suggest that strong negative affective reactions to mobile phone base stations may trigger avoidance motivation ('the farther away, the better' or 'the fewer antennas, the better').

Studies that surveyed participants' knowledge of mobile communication observed low knowledge levels (Ruddat, Sautter, Renn, & Pfenning, 2005; Siegrist et al., 2005; Bianco, Nobile, Gnisci, & Pavia, 2008), low familiarity with EMF key words (Büllingen & Hillebrand, 2005) and incorrect conceptions of EMF exposure magnitudes (Yaguchi, Nobutomo, Shingu, & Miyakoshi, 2000). Studies that used Morgan et al.'s 'Mental Models Approach' (Morgan, Fischhoff, Bostrom, & Atman, 2002) found that laypeople have limited knowledge of interaction patterns between mobile phones and base stations and, therefore, misjudge the resulting exposure magnitudes of both devices. Laypeople perceive the base station as the higher exposure source and underestimate the exposure contribution of their own mobile phone by far (Cousin & Siegrist, 2010c, 2010b). Based on these insights, a new booklet that informs people about the basic functionality of mobile communication and the resulting exposure for users was developed and pretested (Cousin & Siegrist, 2010a). Reading the booklet increased people's knowledge considerably and led to a more adequate risk perception of mobile communication devices. This booklet has also been used in the present experiment (an English version of the booklet can be downloaded at: http://www.cb.ethz.ch/studienergebnisse).

1.2. Rationale of the Present Study

In order to enable the public to make informed decisions, relevant knowledge has to be provided. The present study explores the effects of specific knowledge in the field of mobile communication on base station siting decisions. We hypothesize that specific knowledge enhancement decreases the negative perception of base stations and increases the critical perception of mobile phones (H1). In addition, we assume that participants who are provided with specific knowledge are able to transfer their knowledge to a base station siting scenario and choose sites that account for less radiation for the phoning population (H2). As a third, explorative hypothesis, we tested how emotionally charged information on base stations might affect perception and base station siting preferences. We expected that participants who are confronted with emotionally charged information would choose more remote base stations sites that expose users to more radiation compared with participants not reading an emotional text (H3). Research indicates that the negative affective tone of news media material or a magazine article can have an impact on people's attitudes, intentions and risk perceptions (Lerner, Gonzalez, Small, & Fischhoff, 2003; Yi, 1990). Furthermore, people in an affective focus rely more strongly on associative processes (Scarabis, Florack, & Gosejohann, 2006), which build the basis for immediate affective reactions to a given object. Thus, reading a highly emotional article might trigger negative affect and avoidance of antennas, especially of those antennas that are nearby.

2. Procedure and Materials

Participants were told that the purpose of the study was to survey people's opinion about mobile communication. They were not aware that in fact they were taking part in an experiment with different conditions. The experiment (between-subject design) comprised reading one of three texts that were given in a printed version to participants. Questions concerning these texts, as well as all other dependent variables, were collected on a portable computer (Lenovo 1.8 GHz dual core ThinkPad) using Inquisit software (http://www.millisecond.com). Data collection was done by face-to-face interviews. Participants received a full debriefing after the interview.

2.1. Experimental Design and Questionnaires

Participants were installed in front of the laptop. After some general information was presented on the screen, the computer randomly assigned participants to one of three experimental conditions while controlling for gender. Depending on the experimental condition, the experimenter handed out the corresponding text, and participants were instructed to read it carefully. They had unlimited time to read the text. In Condition 1 (the control group), participants read a neutral text about a historical Swiss abbey. In Condition 2, an information booklet about mobile communication was presented. Participants in Condition 3 read an authentic, emotionally charged newspaper article about a base station siting conflict in a Swiss neighborhood, which had appeared in the news several years before the study was conducted.

Participants who read the informative, neutral text about the Swiss abbey served as the control group; they received no information on mobile communication. Their text had no emotional tone and was matched for length with the text given to the participants in the third condition (word count: 718 words). Thus, we ensured that all groups would be occupied with reading before answering the subsequent questions. In the information booklet presented in Condition 2, the GSM technology and its consequences for radiation exposure were presented. This included information about electromagnetic fields in general, mobile communication networks and their properties in regard to emitted radiation, the current state of research and the remaining scientific uncertainties concerning potential health effects. Special focus was on the interaction patterns of base stations and mobile phones and the resulting EMF emission. For example, the booklet explained that base stations should be located near a phoning person, and not outside urban areas. Otherwise, the mobile phone is required to radiate with higher power to reach the nearest base station. In addition, personal precautionary recommendations were derived and presented in boxes throughout the text. These recommendations, e.g. ‘As far as possible, telephone only when a good connection (signal) quality is available’, were summarized again at the end of the booklet. This text was somewhat longer than the texts of Conditions 1 and 3 (word count 1,210) and included figures and a table. The emotionally charged newspaper article given to participants in Condition 3 described the father of a family who is concerned about the base station planned in his neighborhood. He fears adverse health effects due to the radiation of the antenna as well as a depreciation of his property. He also thinks about launching an initiative against the antenna. Several emotional words such as 'shocked', 'threatening' or 'discomfort' appeared throughout the text.

After the participants read the text, the experimenter removed the texts, and the participants answered the questions. The subsequent questionnaire, which was presented on the laptop, included a manipulation check that measured the impact of the three different texts (two items: informational content and emotional tone), different scales measuring health concerns, benefit and risk perception and affect in regard to mobile communication (each with three items) and a 13-item knowledge test about the technical functionality of mobile communication. The main dependent variable was a base station siting task consisting of 15 forced choices in which participants were asked to select one of two proposed base station siting locations. In addition, participants had to rate each of the proposed base station locations separately with three items. The questionnaire finished with general socio-demographics questions. There were also other measurements that are not relevant for the present paper (e.g. trust in mobile communication stakeholders). After completing the electronic questionnaire, participants received a full debriefing. Participants in Conditions 1 and 3 were also confronted with the information booklet in order to provide them the same information about mobile communication as the participants of Condition 2.

2.2. Participants

The data collection was conducted between May 2009 and July 2009 in the German-speaking part of Switzerland. Eleven interviewers were trained to conduct the interviews. The interviewers recruited the participants by themselves (e.g. at sport clubs, public libraries). They were instructed to interview people between 15 and 75 years of age who own a mobile phone. In addition, the interviewers had to balance gender and education level.

Two hundred and twenty-eight interviews were conducted. Fifty-four percent (n = 122) of the respondents were female, and 46% (n = 106) were male. Reported age ranged between 15 and 74 years. The mean age was 36.10 years (SD = 14.11). Fifty-nine percent of the respondents were between 15 and 34 years of age, 26% were between 35 and 54 years of age and 15% were 55 years or older. Participants were asked to indicate their highest completed education level: 23 (10%) participants were not well educated (primary or secondary school), 66% (150 participants) had achieved a vocational training or a grammar school degree and 24%

or 55 participants were highly educated (university or university of applied science).

3. Results

3.1. Manipulation Checks and Learning Effect of the Booklet

The experimental manipulation was effective. The manipulation check showed that the texts were perceived significantly differently (Table 6.1.): The text of Condition 2 was perceived as significantly more informative than the other two texts and less emotional than Condition 3.

Participants were asked to complete a set of 13 knowledge questions (e.g. A base station gives off the same level of radiation throughout the whole day. When I make a call on my mobile phone, the level of radiation I am exposed to is much higher from my handset than from the nearest base station). The same 13 knowledge questions were used in Cousin and Siegrist (2010a). The response options provided were ‘true’, ‘wrong’ and ‘don’t know’. A summative index counting the number of correct answers was computed. An ANOVA disclosed that the number of correct answers differed significantly between the experimental conditions ($F(2,225) = 113.01$, $p < .001$). Post hoc tests (Tukey’s HSD, Honestly Significant Difference) showed that Condition 2 ($M = 10.42$, $SD = 1.64$) differed significantly from Condition 1 ($M = 5.30$, SD = 2.79) and Condition 3 ($M = 6.82$, $SD = 3.54$). Therefore, the lecture of the booklet significantly enhanced participants’ knowledge.

Table 6.1. Manipulation Check

	Condition 1: Neutral Text *n* = 77		**Condition 2: Information Booklet** *n* = 74		**Condition 3: Newspaper Article** *n* = 77		**ANOVA** *df* (2,225)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*
The text I read was informative.	4.56^{a}	1.22	5.07^{b}	0.97	3.87^{c}	1.24	20.60	.000
The text had an emotional touch.	2.14^{a}	1.12	2.35^{a}	1.25	3.74^{b}	1.32	37.92	.000

Note. Superscript letters ($^{a\ b}$) indicate the significant differences identified by the post hoc tests. Differing letters mark significant differences between the means.

3.2. Perception of Mobile Communication Devices

Each perception construct was measured by three items (see Table 6.2.). A summative index was built for each construct. All constructs had high Cronbach's alphas. As shown in Table 6.3., there are several significant differences between the experimental conditions. Health concerns about base stations and mobile phones were significantly lower in Condition 2 compared to Condition 1. Risk and benefit perception as well as affect in regard to mobile phones did not differ among the three conditions. Affect associated with base stations was significantly more positive for the readers of the booklet than for the other two conditions. To sum up, reading the booklet decreased health concerns and increased the positive perception of base stations.

Table 6.2. Perception of Base Stations and Mobile Phones: Items Used

Constructs and corresponding items (rating scales)
Health concerns mobile phone *(1 = no concerns at all; 6 = very high concerns;* α = .867)
1.) I am concerned that radiation emitted by my mobile phone affects my health in the long run.
2.) I am concerned that the radiation emitted by my mobile phone affects my immediate wellbeing.
3.) I am concerned that in the long run the radiation emitted by mobile phones affects people's health negatively.
Health concerns base station *(1 = no concerns at all; 6 = very high concerns;* α = .906)
1.) I am concerned that radiation emitted by base stations affects my health in the long run.
2.) I am concerned that the radiation emitted by my base stations affects my immediate wellbeing.
3.) I am concerned that in the long run the radiation emitted by base stations affects people's health negatively.
Benefit perception *(1 = no benefit al all; 6 = very high benefit;* α = .885)
1.) Overall, I associate mobile communication with…
2.) I associate base stations with…
3.) I associate mobile phones with…
Risk perception *(1 = no risk at all; 6 = very high risk*; α = .893)
1.) Overall, I associate mobile communication with…
2.) I associate base stations with…
3.) I associate mobile phones with…
Affect base station *(1 = negative; 6 = positive*; α = .928)
1.) How do you valuate base stations overall?
2.) When I think about base stations my thoughts are predominantly...
3.) When I think about base stations my feelings are predominantly...
Affect mobile phone *(1 = negative; 6 = positive*; α = .935)
1.) How do you valuate mobile phones overall?
2.) When I think about mobile phones my thoughts are predominantly...
3.) When I think about mobile phones my feelings are predominantly...

Table 6.3. Means and SD of All Perception Measurements for Each Experimental Group

	Condition 1: Neutral Text *n* = 77	**Condition 2: Information Booklet** *n* = 74	**Condition 3: Newspaper Article** *n* = 77	**ANOVA** *df* (2,225)	
	M (SD)	*M (SD)*	*M (SD)*	*F*	*Sig.*
Health concerns base station	3.59 (1.15)[a]	2.95 (1.06)[b]	3.34 (1.27)[ab]	5.769	**.004**
Health concerns mobile phone	3.65 (1.13)[a]	3.08 (1.07)[b]	3.30 (1.26)[ab]	4.765	**.009**
Risk perception	3.58 (0.93)	3.32 (0.99)	3.53 (1.07)	1.453	.23
Benefit perception	4.87 (0.87)	4.83 (0.92)	4.69 (1.01)	0.788	.47
Affect base station	3.00 (0.97)[a]	3.45 (1.13)[b]	2.93 (0.97)[a]	5.531	**.005**
Affect mobile phone	4.32 (0.87)	4.39 (1.02)	4.32 (1.09)	0.145	.865

Note. The reported means represent the summative index of three items each. Superscript letters ([a b]) indicate the significant differences identified by the post hoc tests. Differing letters mark significant differences between the means. 1 = low value of the construct or negative; 6 = high value of the construct or positive (see Table 6.2. for details).

3.3. Base Station Siting Preferences

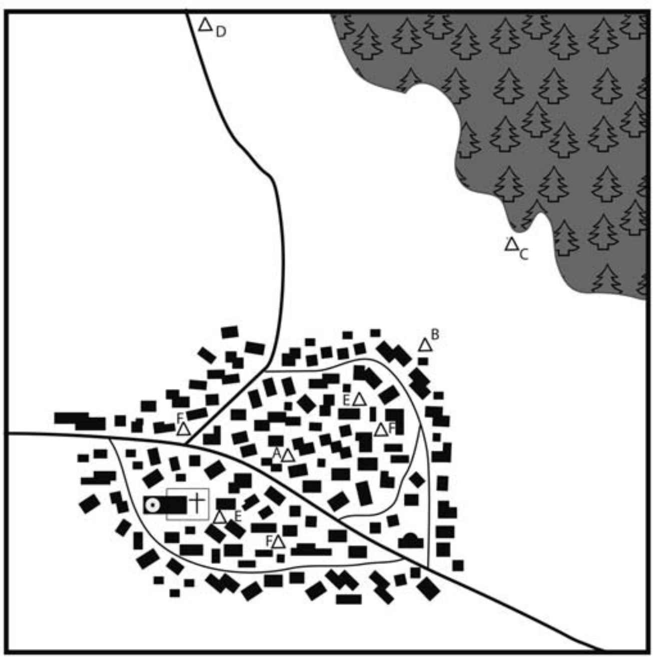
In the base station siting task, participants were asked to indicate their preferences concerning base station siting in a forced-choice task. Six different scenarios, presented as map segments, were used. Respondents were asked to compare all possible pairs of scenarios and, for each pair, to indicate their preferred option. In Figure 6.1., the six scenarios and their verbal descriptions are combined into one figure. The following instructions were provided to participants:

> In each of the following questions, you will see two different diagrams, each showing the layout of the same village. There are various ways in which the entire village can be provided with full signal coverage by the mobile phone network. In each case, please decide which variant you would choose from the point of view of the village as a whole. The position of the base station is represented by a red triangle. Below each diagram, there is also a written description of the situation. All of the base stations belong to the same service provider.

In every combination, one scenario provides objectively less radiation for the phoning population than the other scenario. Generally, mobile phone use accounts for more individual exposure than base stations do. To minimize emitted radiation by mobile phones, as well as overall exposure, siting base stations as close as possible to the phoning population is advised.

Therefore, distant base stations (edge of the village, edge of the woods, edge of the street) are less favorable than nearby ones. The scenario with two half-power base stations or three third-power antennas would result in the lowest radiation level for the phoning population.

Based on these objective preferable options, a summative index counting the number of chosen better options was calculated (Min = 0; Max = 15). Mean values differ significantly between the three experimental groups ($F(2,225) = 55.11$, $p < .001$). The readers of the booklet (Condition 2: $M = 11.89$, $SD = 3.86$) scored significantly higher than the other two groups (Condition 1: $M = 5.71$, $SD = 4.77$; Condition 3: $M = 5.00$, $SD = 4.70$). The technical information provided by the booklet resulted in better choices with lower exposure.



A. A single base station is centrally located in the middle of the village.
B. A single base station is located at the edge of the village.
C. A single base station is located at the edge of the woods, away from the village.
D. A single base station is located beside the street, far away from the village.
E. Two small half-power base stations are installed at different locations in the village.
F. Three small third-power base stations are installed at different locations in the village.

Figure 6.1. Base station siting task.

In addition to the siting task, participants were asked to assess the acceptability of every scenario separately (see Table 6.4.). Therefore, participants indicated their disagreement (1 = I do not agree at all) or agreement (6 = I agree strongly) to three statements each on a six-point scale (1. This base station location is… / These base station locations are good for the entire village community and me. 2. This base station location provides… / These base station locations provide a low exposure rate for the entire village community and me. 3. This base station location constitutes… / These base station locations constitute a health risk for the entire village community and me). Cronbach’s alphas ranged between $\alpha = .600$ and $\alpha = .761$.

Again, summative indexes of the three items were built. Table 6.4. reports the overall assessments of every scenario. All three experimental groups perceived the scenario with one base station at the edge of the village similarly. In all the other scenarios, the perception of the group who read the information booklet differed significantly from the other two groups. The means reveal that the latter used two heuristics, ‘the farther away, the better’ and ‘the fewer antennas, the better’, whereas participants who read the booklet used the opposite heuristics (‘the nearer, the better’, ‘the more antennas, the better’). Thus, they were able to transfer the information given in the booklet to the base station siting task and correctly inferred that a higher number of antennas and a central location in the village would be better options for the village community.

Table 6.4. Evaluation of the Six Base Station Locations

	Condition 1: Neutral Text n = 77	**Condition 2: Information Booklet** n = 74	**Condition 3: Newspaper Article** n = 77	**ANOVA** *df* (2,225)	
	M (SD)	*M (SD)*	*M (SD)*	*F*	*Sig.*
One base station, center	2.57 (1.08)[a]	3.61 (1.04)[b]	2.61 (1.16)[a]	21.62	**.000**
One base station, edge of village	3.18 (0.73)	3.16 (0.85)	2.98 (1.01)	1.19	.305
One base station, edge of the woods	4.01 (0.99)[a]	3.04 (1.05)[b]	3.82 (1.10)[a]	18.29	**.000**
One base station, edge of the street	4.27 (1.19)[a]	2.93 (1.11)[b]	4.13 (1.24)[a]	29.50	**.000**
Two half-power base stations	2.99 (0.94)[a]	3.94 (0.80)[b]	2.89 (1.12)[a]	27.28	**.000**
Three third-power base stations	3.05 (1.10)[a]	4.10 (1.10)[b]	2.97 (1.35)[a]	20.55	**.000**

Note. The reported means represent the summative index of three items each. Superscript letters ([a b]) indicate the significant differences identified by the post hoc tests. Differing letters mark significant differences between the means (1 = I do not agree at all; 6 = I agree strongly).

4. Discussion

Base station siting frequently results in conflicts with parts of the concerned population (Burgess, 2002, 2004). Intuitively, people would place base stations far away from the users (Cousin & Siegrist, 2010b; Dohle et al, 2010a). Unfortunately, this choice would lead to higher exposure because the most important radiation source is the user's own mobile phone (IEGMP, 2000; Neubauer et al., 2005). The farther away base stations are placed from the user (or the worse the connection is), the more the mobile phone is forced to radiate in order to reach the nearest base station. Previous research has shown that people lack relevant knowledge about the functionality of mobile communication in order to assess the amount of radiation they are exposed to (Cousin & Siegrist, 2010b, 2010c).

In the present paper, we explored whether specific knowledge about the technological functionality of mobile communication and the resulting exposure may affect people's perception of mobile communication as well as their base station siting preferences. We hypothesized that specific knowledge enhancement would decrease the negative perception of base stations and increase the negative perception of mobile phones (H1). In addition, we assumed that specific knowledge leads to better base station siting choices (H2). As a third, explorative hypothesis, we tested whether emotionally charged information would lead to worse base station siting choices (H3).

These hypotheses were tested in an experimental setting in which we confronted participants with three texts: A neutral text, an information booklet about mobile communication or an authentic emotionally charged newspaper article about a base station siting conflict in a Swiss neighborhood.

We found partial support for the first hypothesis. Reading the information booklet led to a decrease in negative perception of base stations. Participants confronted with the information booklet rated base stations as less negative and indicated fewer health concerns in regard to base stations. Contrary to Hypothesis 1, the health concerns in regard to mobile phones decreased as well. However, there was no difference in the affective rating between the three experimental conditions. In sum, the information provision seemed to correct participants' perception, especially of base station emission and to complete participants' knowledge about exposure dynamics.

As Hypothesis 2 stated, the specific knowledge enhancement led to changed base station siting preferences. Participants who read the information booklet were able to transfer the technical knowledge they had gained to a task that consisted of siting a base station in a hypothetical village. Apparently, the technical information given in the booklet enabled them to choose the scenarios that emit less radiation to mobile phone users. The Condition 2 participants applied decision heuristics different from those of the other participants. The heuristics of participants who read the booklet can be broadly described as ‘the nearer the antenna, the better’ and ‘the more antennas, the better’. These choices would provide less radiation to mobile phone users. Adequate knowledge helps people to understand current base station siting practice and its advantages.

The third, explorative hypothesis was not supported by the data. Emotionally charged information in the form of a newspaper article did not enforce participants’ tendency to ban antennas outside the village and to decrease the number of antennas, although the manipulation check indicated that the manipulation was successful. Furthermore, participants who were confronted with the newspaper article also indicated similar risk perceptions and affect of base stations and mobile phones as participants reading the neutral text. Thus, this research stands in contrast to Lerner et al.’s (2003) study, which indicated that fear triggered by a picture and a text from the news media increased risk estimates. Results also differ from a study in the field of advertisement, which has shown that the negative affective tone of a magazine article leads to more negative attitudes towards the ad (Yi, 1990). However, participants in the present study may have noticed the emotional tone of the article but nonetheless did not identify with the concerned resident. Furthermore, mobile communication risk may have been of only minor importance for the participants. Affect determines risk perceptions more strongly when issue importance is high (Earle & Siegrist, 2008). In daily life, people are often confronted with this type of information about mobile communication (Litmanen & Tuikkanen, 2008; Elvers, Jandrig, Grummich, & Tannert, 2009). The result can be seen as a sign that a single negative or emotionally charged reporting of base station siting conflicts has limited impact on readers’ perception of mobile communication and the associated base station siting preferences. The impact of technical facts seems to have the bigger effect of immediate assessment than an emotionally charged article. Research by Ruddat et al. (2010) points in the same direction. They found that their participants were able to identify biases in information, regardless of their own view and whether they rejected obviously exaggerated or downplayed information.

Some limitations of the study results need to be mentioned. In order to diversify the background and previous knowledge, we chose to interview people from the general public rather than students. However, the present study still used a convenience sample and might, as all experimental studies, have limited generalizability. More crucial are the following limitations: First, in reality laypeople are mostly not involved in the site selection of base stations (Mobile Operators Association [MOA], 2006). Therefore, the results are somewhat speculative, but they give clear indication that people lack specific information and that information provision would alter people's preferences. Secondly, the participants chose a base station location in a hypothetical village. When it comes to a new base station siting project in the participants' own village, other factors (e.g. other environmental burdens, placement of the local school or kindergarten, trust in the involved authorities) probably affect people's decisions. However, information about the technical functionality of mobile communication and the resulting exposure would at least not increase risk perception and health concerns. It is also important to keep in mind that technical information like that given in this experiment is only a part of the relevant information in order to form opinions about mobile communication risks. Information from various media, knowledge about regulation and decision-making are important, too. More generally, the perception of a technology is largely caused by the societal framework in which the technology is embedded (e.g., Pidgeon et al., 2003).

The present study showed that people lack specific information about the functionality of mobile communication and the resulting exposure magnitudes. Provision of this knowledge would help people to better understand authorities' base station siting policies and, if wished, decrease radiation emission from the own mobile phone. Even when it takes some effort to provide information about technical functionality and the resulting exposure, these topics need to be included in effective risk communication approaches in order to help people make informed decisions.

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Chapter VII

General Discussion

1. Discussion

The present work examined the perception of non-ionizing radiation. Non-ionizing radiation risks, in particular mobile communication, can be perceived quite differently by different groups of people. In everyday life, these differences become apparent in the metaphors chosen by the conflicting parties. Opponents of mobile communication often argue that, in the past, some hazards have been ignored by experts, and finally emerged to be quite harmful to health, such as smoking or asbestos. Advocates of the mobile communication technology, on the other hand, quote different examples. They believe that the prosperity of society is largely based on technical advances such as electricity, automobiles, and, finally, mobile phones, and testing these technologies before they come on the market would counteract technological progress.

Why is the same technology perceived so differently? The reasons for these differences are manifold; thus, various methods were used in the present work to explore this question. In the two studies presented in Chapter II, a SC-IAT was employed (Karpinski & Steinman, 2006), which is a method for measuring implicit attitudes based on reaction times. A free association technique designed to collect and categorize associations to mobile phone base stations was applied in the following chapter. In order to analyze the causal relationships between cognitive appraisals, specific emotions, and risk judgments, structural equation modeling was used in Chapter IV. Furthermore, a conjoint analysis—a method that determined how people value different attributes of mobile phone base stations—was presented in Chapter V. An experiment finally investigated how knowledge influences siting decisions (Chapter VI).

To facilitate a critical discussion of these studies, an overview of the central results will be presented first in this concluding chapter. Subsequently, consequences for risk communication will be discussed. At the end of this chapter, several limitations as well as implications for future research will be addressed.

2. Central Findings

Five main findings stand out in this research. First, the studies showed that affect determines the perception of non-ionizing radiation and other risks. Second, this research demonstrated that affect toward mobile communication differs among experts, opponents, and laypeople. Third, the studies found that risk perception differs due to important demographic variables. Fourth, the research corroborated that knowledge influences base station siting decisions. And last, evidence was provided that citizens prefer distant and covered base station sites. In the following sections, these results will be discussed in detail.

2.1. Affect Determines the Perception of Non-Ionizing Radiation and Other Risks

The psychometric paradigm (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, 1987) aims at identifying the underlying factors in risk perception. These studies have revealed that a so-called *dread risk* factor, which is supposedly strongly linked to affect (Slovic, Finucane, Peters, & MacGregor, 2002; Visschers & Siegrist, 2008), is a major determinant of public perception and acceptance of risk for a wide range of hazards. It is important to keep in mind, however, that no systematic research has yet tested the hypothesis that this factor is closely linked to affect. Sjöberg (2007), for instance, has questioned this assumption by pointing to the fact that the dread risk factor is not made up of affective or emotional items but rather consists primarily of several cognitive items (such as the severity of consequences). Using an implicit method based on reaction times (the SC-IAT; cf. Karpinski & Steinman, 2006), the present work supports the idea that the dread risk dimension of the psychometric paradigm is strongly related to immediate affective reactions toward risks (Chapter II, Study 2). Because the dread risk factor usually explains a large amount of the variation of public risk perception, the findings suggest that risk perception is largely determined by affect.

Affect can also be measured by utilizing imagery techniques such as the free association tasks (Finucane, Slovic, & Mertz, 2000; Siegrist, Cousin, Kastenholz, & Wiek, 2007; Slovic, Flynn, & Layman, 1991). In Chapter III, results of free associations to mobile phone base stations were presented. This technique was used to complement the results of the SC-IAT because free associations give more specific insights about the words or images that people have in mind when they evaluate risks. It could be demonstrated that thinking about mobile phone base stations entails various negative affective images such as “negative consequences,” “esthetic aspects,” or “radiation.” Furthermore, the images differed among people with low, medium, and high risk perception: participants with high risk perception mainly mentioned associations such as “senselessness” or “hazard,” while participants with low risk perception often expressed associations such as “science” or “camouflage.” A related study (Chapter IV) also showed that not only global affect but also specific emotions such as anger and fear influence perceived risks, benefits, and the acceptance of a hazard. Notably, the research found that risk perception was more strongly influenced by fear than by anger. Benefit perceptions and the acceptance of base stations, on the other hand, were determined by anger.

Taken together, the results of these studies suggest that mere affect serves as a fast, frugal, and first evaluation of mobile communication and other risks. This first evaluation tells us whether the stimulus is good or bad for us, or in other words, if it is personally relevant. According to the affect heuristic, this evaluation stems from an affect pool: "All of the images in people's minds are tagged or marked to varying degrees with affect. An individual's 'affect pool' contains all of the positive and negative markers associated (consciously or unconsciously) with the images. The intensity of the markers varies with the images" (Slovic, Peters, Finucane, & MacGregor, 2005, p. S36). In the field of neuroscience, such signals are considered conscious or non-conscious *somatic* markers to denote that they are embodied, i.e., that they include visceral and nonvisceral sensation (Damasio, 1994). However, daily experience tells us that affective reactions can be quite manifold and complex. Indeed, the findings of the present work suggest that the global evaluation of a hazard is also accompanied by more specific emotions. The results of the study presented in Chapter IV, for instance, suggest that fear and anger are crucial emotions in the field of mobile communication. These emotions were triggered by appraisals of fairness and control. Hence, it is important to consider not only global affect but also specific appraisals and emotions to gain more insights about people's risk perception (Zeelenberg, Nelissen, Breugelmans, & Pieters, 2008).

In addition, it was shown that affective reactions to mobile communication were also strongly related to trust. These results are in line with a study conducted by Siegrist et al. (2007), which demonstrated that social trust influences affect. In contrast to the study by Siegrist and colleagues, affect was measured using an implicit task in this work (Chapter II), which is tenably a more appropriate proxy for affect in risk perception. The findings suggest that the relationship between affect and trust is remarkably strong: Of all the implicit-explicit correlations examined in Chapter II, the correlation of the Base Station SC-IAT with trust was the highest. Both trust and affect have also been discussed as important determinants of the inverse relationship of risk and benefits (Siegrist & Cvetkovich, 2000; Slovic et al., 2002). Little is known, however, about the direction of the relationship. It is possible that affect influences social trust, but likewise, general affective reactions may also shape social trust (for a discussion on this issue, see Visschers & Siegrist, 2008). Hence, more research is necessary to explore the cause-and-effect chain of affect and trust in risk perception.

2.2. Affect Toward Mobile Communication Differs Among Experts, Opponents, and Laypeople

Chapter II also demonstrated that experts, base station opponents, and laypeople differ in their immediate affective associations to mobile phones and mobile phone base stations, which were measured using the SC-IAT. Base stations evoked positive implicit associations in a group of experts on mobile communication, neutral associations in a laypeople group, but negative associations in a group of base station opponents. In the subsequent chapter, in which the free association technique was employed, considerable differences in the affective images mentioned by experts and base station opponents were found as well (Chapter III, Study 1). While base station opponents think more often of “negative consequences” than laypeople or experts, the latter more often mention “technical concepts” of mobile phone base stations.

It is known from the existing literature that experts and laypeople often differ in the perception of risks (Fischhoff, Slovic, & Lichtenstein, 1982; Kraus, Malmfors, & Slovic, 1992; Savadori et al., 2004; Sjöberg, 1998; Thomson, Onkal, Avcioglu, & Goodwin, 2004). Various reasons for expert-laypeople differences, such as role conception or knowledge deficits, have been suggested (Sjöberg, 2002). In an extension, the results of the two studies mentioned above suggest that differences in risk perception between laypeople and experts are due to different affective reactions to technologies. Because the groups were matched according to age, gender, and education, this result cannot be ascribed to demographic variables.

These studies, however, cannot determine where these differences derive from. It is possible that differences in affect can be explained by an underlying second factor. That is, it is possible that affect is only the consequence of another important variable. Long experience (i.e., familiarity) may have habituated experts to mobile communication risks, and thus, experts evaluate these risks less negatively. Similarly, experts might sense that they have more control over these risks. Control, as shown in Chapter IV, is a crucial factor in the perception of mobile communication risks, and opponents may show more negative affect because they perceive less control over base stations than expert. Furthermore, the free association task revealed that experts often think of the technical concepts of base stations, while opponents more often think of the negative consequences of base stations. Thus, experts may much more interested or even enthusiastic about technologies than others, which makes experts think more optimistically about the risks (and which also may have led experts to choose their respective profession). While the present work was able to demonstrate that there are differences in affect among experts, opponents, and laypeople, future studies might want to address the question where these differences stem from.

2.3. Risk Perception Differs Due to Important Demographic Variables

In the above-mentioned studies that contrasted experts, base station opponents, and laypeople, demographic variables were controlled by a matching procedure. In other studies presented in this work, demographic variables were not specifically controlled, but nonetheless surveyed in order to determine their influence on risk perception. The results of the second study regarding free associations to base stations (Chapter III) and findings of the conjoint analysis (Chapter V) indicated that age and gender are important demographic variables that influence the perception of mobile communication. The free association task showed that younger respondents attribute fewer risks to mobile phone base stations than older respondents. Presumably, younger participants are also more familiar with mobile communication, and according to Sandman’s public outrage theory, familiarity is an important factor that diminishes people’s worries about risk (Sandman, 1987, 1993).

Gender effects were primarily revealed in the conjoint analysis. Participants within the cluster that preferred a base station location in the middle of the village (i.e., a more advantageous site in regard to precautionary health protection) were predominantly male. These participants also perceived fewer risks and more benefits from mobile communication, too. Interestingly, the cluster was also characterized by more knowledge concerning the interaction patterns of mobile phones and base stations. Therefore, it stands to reason that males generally possess more knowledge in regard to mobile communication, although the relationship between gender and knowledge was not directly tested in this work. However, Cousin and Siegrist (2010a) provided evidence that older participants, as well as females, have less knowledge in the domain of mobile communication. Thus, for risk communication purposes, these results imply that knowledge should be provided particularly to women and older people.

2.4. Knowledge Influences Base Station Siting Decisions

Effects of knowledge about mobile communication have been previously investigated by Cousin and Siegrist (2009, 2010a). The authors have shown that information on mobile communication influences health concerns, and can lead to behavioral changes (Cousin & Siegrist, 2009). In a related study, the authors also demonstrated that participants with a higher level of knowledge (as measured by a scale that covered different technical domains) often chose base station locations that minimized radiation for the phoning population (Cousin & Siegrist, 2010a). However, these data are based on correlational data. In contrast to the study conducted by Cousin and Siegrist (2010a), knowledge was experimentally manipulated in the present work in order to support a causal relation between knowledge and siting decisions (Chapter VI). Some participants were provided with information on mobile communication, while other participants either received emotionally laden information or no information. Compared with the other conditions, knowledge provision was shown to have an influence on a realistic base station decision: participants who were provided with knowledge preferred locations in the center of the village, which would be the best location from a public health perspective (Cousin & Siegrist, 2010a; WHO, 2000). Compared to the control group, participants who were provided with knowledge also indicated more positive explicit affect and fewer concerns in regard to mobile phone base stations.

These results stand in contrast to other studies that only found weak and inconsistent effects of knowledge enhancement on risk perception (Kennedy, Probart, & Dorman, 1991; MacGregor, Slovic, & Morgan, 1994; Morgan et al., 1985; Sjöberg & Drottz-Sjöberg, 1991). It is possible that knowledge plays an important role for some hazards, but not for others. For example, it is possible that hazards that load very highly on the dread risk dimension of the psychometric paradigm might be less responsive to knowledge provision than other risks. As shown in Chapter II, the dread risk dimension is closely related to affect, which is located in the experiential system. Knowledge, in contrast, is part of the analytic system (Slovic, Finucane, Peters, & MacGregor, 2004). Mobile communication is perceived as moderately dreadful (Bronfman & Cifuentes, 2003; Siegrist, Keller, & Kiers, 2005), and it has been proved that people have knowledge gaps in regard to this technology (Cousin & Siegrist, 2009, 2010a, 2010b). The latter finding, which was derived by applying the mental models approach, indicated that technical knowledge is important for the perception of mobile communication risks. Due to these results, knowledge gaps could be specifically addressed in the booklet used in Chapter VI. The lack of a relationship between knowledge and decision making in other studies might also be ascribed to methodological factors. Other studies often captured knowledge using single questions or self-assessments, which are less accurate than objective scales consisting of multiple items. The studies conducted by Cousin and Siegrist (2009, 2010a) and the studies presented in Chapters V and VI highlight that the assessment of *objective* knowledge is crucial to examining knowledge influences on the perception of mobile communication.

2.5. Citizens Prefer Distant and Covered Base Station Sites

The conjoint analysis (Chapter V) was based on a large-scale sample and gave insights into public preferences in regard to mobile phone base stations. In most countries—and also in Switzerland—citizens are not allowed to participate in the decision-making process regarding a base station. If people could decide about the base station's site in Switzerland, the conjoint analysis indicated that the majority of citizens would prefer a covered base station that is mounted on a factory. From the public's point of view, it would also be important that residents can participate in the decision process, and that the base station is located far away from the center of the village.

In combination with the results of Chapter III (where participants freely associated about mobile phone base stations), the results of the conjoint analysis also emphasized that esthetic aspects play an important role in the acceptance of mobile phones. The conjoint analysis has shown that participants reject freely visible base stations. Likewise, the free association method revealed that esthetic aspects are important for many people: Across two studies (one exploring differences among experts, opponents, and laypeople and another collecting associations from a large sample from the general public), esthetic aspects were mentioned frequently. Based on these results, public authorities or mobile phone providers may want to consider altering the appearance of base stations. It should be noted, however, that changing the appearance of a base station should be considered with caution. Although citizens would appreciate covering the base station (e.g., with a sheeting), some people clearly disapprove of a camouflaged base station (e.g., as a tree or a crucifix).

3. Consequences for Risk Communication

In addition to suggestions concerning the appearance of a base station, the results of the present work involve various other implications for risk communication. To facilitate informed decision making, means of optimizing risk communication will be discussed more deeply in the following.

Chapter IV has indicated that a lack of control is crucial for the development of fear and anger in the context of mobile communication. These emotional responses are in turn important for risk and benefit perceptions and the acceptance of base stations. Thus, one way to reduce negative affective reactions toward mobile phone base stations would be to implement control, which is strongly related to fairness (Smith & Ellsworth, 1985). Facilitating a reciprocal communication process, in which citizens have the possibility of expressing their needs (Renn & Levine, 1991), and involving citizens in the base station siting process are options for reaching this aim. In most countries, however, citizens have only a small voice in siting decisions. It is noteworthy, however, that countries or provinces that give citizens the opportunity to co-determine base station sites have gained a positive experience with this approach (Kastenholz & Benighaus, 2003).

At the same time, it is important that citizens are adequately informed when making choices about the location of base stations (Stewart, 2000). As indicated by Chapters V and VI, people arrive at different conclusions when they are adequately informed about the interaction of mobile phones and their base stations. Therefore, an information booklet on mobile communication provided in order to enable informed decision making should include an explanation about how radiation decreases with distance from the base station (Stewart, 2000). Likewise, such a booklet should contain precautionary recommendations referring to the users' mobile phones. These recommendations would enable users to avoid unneeded exposure, which could also lead to a heightened sense of control. A communication example that takes these issues into account was given in Chapter VI, which used a booklet developed by Cousin and Siegrist (2009). Interestingly, this booklet was able to change explicitly stated affect, which might be due to a heightened sense of control.

Another way to implement control could be the provision of exposimeters to citizens who want to be informed about their personal daily exposure. Exposimeters display personal radiofrequency electromagnetic field exposure. Europeans most frequently mention mobile phones and mobile phone base stations as a source of EMF (European Commission, 2007). Only a few people know, however, that home appliances, computers, induction heaters, and cordless home telephones are sources of EMFs, too. Exposimeters are a way to visualize these EMFs. Thus, citizens would have the opportunity to compare the radiation of mobile communication to other sources of EMF. If individuals wish to minimize their daily exposure, the exposimeters' results would indirectly provide instructions on how to act. For instance, if exposure from the cordless home telephone is relatively high (which is often the case), the person might think about replacing it with a phone connected by wire. Another possibility for implementing perceived control could be the integration of a scale on mobile phones that displays exposure in relation to international exposure limits. This implementation, of course, would be possible only with the collaboration of the industry.

From the perspective of dual process models, it seems to be important that risk communication material addresses not only the analytic system but also the experiential system (cf. Slovic et al., 2004). The present work strongly suggests that affect, which is part of the experiential system, is an important factor in the perception of mobile communication. The exposimeters as well as a visual scale displayed on mobile phones have the advantage that they may address the experiential system more strongly than the analytic system. More generally, images, metaphors, and narratives are assumed to have a stronger impact on the experiential system than logic or reasoning (Slovic et al., 2004). Therefore, it is also reasonable to assume that audiovisual material (less than text material) is effective for risk communication purposes. In fact, there is evidence that a video's audiovisual material primarily affects people's immediate gut feeling about a risk or, in other words, the experiential system (Visschers, Meertens, Passchier, & de Vries, 2008). In contrast, a video's text designed to inform about a risk particularly affects cognitive processes.

The present work also highlighted the importance of trust for risk communication. The conjoint analysis has indicated that people who preferred central base station locations were also characterized by higher trust in mobile communication authorities. Similarly, Chapter II (in which the IAT was employed) emphasized the close relationship between affective reactions and trust. It is also known from other studies that trust is an important factor in risk perception (Siegrist & Cvetkovich, 2000), especially when people lack the knowledge about a hazard—which is typically the case for mobile communication (Cousin & Siegrist, 2010a). Thus, for risk communication purposes, it is important to ensure contexts in which trust can grow and establish. The TCC Model suggests that social trust is directly influenced by value similarity (Earle, Siegrist, & Gutscher, 2007). Furthermore, it is known from the literature that trust is difficult to acquire but easy to lose (Slovic, 1993, 1999). Thus, if public authorities or companies convey that they do not care about the public and open dialogues, or demonstrate that they have different values than the public, trust might be destroyed beyond repair. Risk managers are well advised to communicate the values that are compatible between themselves and the public, in particular in crisis situations (Siegrist, Gutscher, & Keller, 2007). In the field of mobile communication, it has also been suggested that information about the location and operating characteristics of all base stations in a country might foster trust, and should be revealed to the public (Stewart, 2000).

4. Limitations and Future Studies

The present work concentrated on the perception of mobile communication risks and found that affect largely determines the perception of this technology. Thus, the present findings set the stage for examining how risk communication might change affect, or in particular, implicit evaluative associations. Chapter VI provided evidence that knowledge provision is able to change explicitly stated affect to base stations. However, it would be even more interesting and compelling when such impacts could also be detected by the SC-IAT. Future work could explore, for instance, what kind of information is useful for changing implicit associations to mobile communication or whether a one-time or repeated information provision is necessary to change implicit associations.

Future studies in risk perception might also want to address how specific emotions to different hazards can be influenced. For mobile communication, the structural equation model presented in Chapter IV demonstrated that control and fairness influence anger and fear. In this study, people were asked about their perceived control and fairness regarding mobile phone base stations, which differed among participants. However, this study cannot determine whether perceived and induced control (i.e., experimentally manipulated) influence fear and anger in the same way. A systematic experiment could close this gap. If induced control leads to the same effect as perceived control, control would be a crucial and modifiable parameter that has the ability to change emotional reactions to risks.

Other studies might want to concentrate on influencing global affect per se. Little is known about the origination and development of affect (Spence & Townsend, 2008). As emphasized in the introductory section, affect refers to the valence of a stimulus. It has been proposed that *evaluative conditioning* is a way to change the valence of a neutral stimulus by pairing it with another, liked or disliked, stimulus (De Houwer, 2007; De Houwer, Thomas, & Baeyens, 2001). The effect of evaluative conditioning is often used in ads, when a neutral object (e.g., a car) is repeatedly presented together with images of smiling people. However, a word of caution seems appropriate here. First, the theoretical understanding of evaluative conditioning is quite limited (De Houwer, 2007). There are many conflicting results about the conditions under which this phenomenon occurs. Second, from an ethical point of view, it is questionable whether affective reactions to hazards should be changed at all. In contrast to knowledge, there is no clear and straightforward criterion what kind of affective reactions to hazards are correct or false. Instead of trying to alter affective reactions per se, it seems more appropriate to examine (and potentially change) the eliciting conditions that trigger affective reactions toward risks, such as the lack of control in the case of mobile communication.

In this sense, it would also be interesting to see if the public's global affect or free associations to mobile phone base stations change over time, and which influences lead to such a change. For example, it could be investigated if media coverage on mobile communication contributes to a change in affect and perception of mobile communication. According to the social amplification of risk framework (Kasperson et al., 1988; Renn, Burns, Kasperson, Kasperson, & Slovic, 1992), news media act as important amplification stations for public perceptions and responses to risks. Thus, it could be interesting to analyze how media reports present information about mobile communication. Similarly, one could investigate how the public interprets press articles, TV, and radio program broadcasts on this topic. For example, laypeople might overestimate the frequency of studies that demonstrate adverse health effects because such studies are discussed more often in the media than studies that show no effects—regardless of the study quality (Burgess, 2004; Elvers, Jandrig, Grummich, & Tannert, 2009). Furthermore, seeking balance in stories is an important principle of professional journalism. However, giving all sides their respective points of view might lead to the misimpression that adverse health effects of mobile communication are highly probable.

Moreover, future studies might want to extend the scope of the present work. The focus of the studies was mobile communication. Nonetheless, it would be interesting to explore how the public perceives other sources of non-ionizing radiation. Previous studies have applied the psychometric paradigm to address this research question (Bronfman & Cifuentes, 2003; Siegrist et al., 2005). Multidimensional scaling (Kruskal & Wish, 1978) might be another option for investigating how different sources of non-ionizing radiation are evaluated and how they relate to each other. Multidimensional scaling enables a researcher to reveal the basic perceptual dimensions of data based on proximities. Therefore, using this method, it is possible to explore which sources of non-ionizing radiation are perceived as similar. Multidimensional scaling could be an interesting method for newly developed technologies, such as private or public wireless local area networks (WLAN). For example, whether WLAN is perceived as similar to computers or similar to mobile phones could be explored. Likewise, the location of public WLAN in the multidimensional scaling configuration might be different for participants who already use this technology.

Finally, it is worth mentioning that the field of social psychology has recently been criticized for neglecting actual behavior in its studies (Baumeister, Vohs, & Funder, 2007). In the present studies, care was taken to design choice tasks as realistically as possible (e.g., the base station siting task), but no actual behavior was investigated. Thus, it cannot be excluded that citizens would decide differently about the site of a base station if they had to irrevocably choose the site of a base station in their neighborhood. Certainly, citizens' actual siting behavior can hardly be observed, because laypeople (at least in Switzerland) do not participate in siting decisions. Nonetheless, future studies might want observe if affective reactions toward mobile communication influence, for instance, other actual behavior such as phoning duration and frequency.

5. Conclusion: Affective Rationality or Affective Delusion?

There is a popular belief that wise decisions come only from cool heads, and that good judgments should not be based on emotions (Damasio, 1994). In fact, there are instances when emotions can be misguiding and deluding. The downside of affect is revealed, for instance, when pleasant music in a supermarket encourages customers to buy more products, or when attractive pictures seduce people to smoke cigarettes. In particular, research has shown that emotions are actually harmful to decision making when they are incidental, i.e., unrelated to the decision task at hand (Damasio, 1994; Zeelenberg et al., 2008).

However, when emotions are integral to the decision being made, they serve as important cues in order to come to fast and advantageous decisions. Many studies have demonstrated that knowledge and reasoning alone do not suffice for sound and rational decision making (Damasio, 1994). Human beings require emotional signals, or somatic markers, because such a signal "forces attention on the negative outcome to which a given action may lead, and functions as a alarm signal which says: Beware of danger ahead" (Damasio, 1994, p. 173). Perceiving and integrating these affective feelings mean that we become rational actors in numerous important situations (Slovic et al., 2002), and, ultimately, ensure survival (Damasio, 1994). Humans feel, therefore they are.

The present work has highlighted and supported the idea that affective reactions are also crucial for the perception of risks. These reactions occur rapidly and, apparently, mostly automatically. And, instead of deluding rational risk judgments, they can serve decision making in their own right. Thus, affective and emotional reactions to risks should not be disregarded or ignored. Instead, the investigation of affect is necessary to thoroughly understand people's perception of risk.

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Summary

Non-ionizing radiation is ubiquitous in the human environment. Some sources of this radiation are natural, while others, like mobile communication, are human-made. In the case of mobile communication, little is known about whether long-term exposure to the radiation of mobile phones and mobile phone base stations leads to adverse health disorders. Accordingly, many citizens are concerned about the rapid growth of this technology. The present work investigates which factors determine perceived risks and benefits of mobile communication, and also the acceptance of this technology. Specifically, the work examines the role of affect in risk perception, since previous research has indicted that affect can serve as an important shortcut within decision making.

Various methods were used to investigate the influence of affect on the perception of mobile communication. Chapter I develops the central research questions of this work and gives an overview of the methodology. Chapter II presents results of a Single Category Implicit Association Test, which indicated that affective evaluations of different risks are carried out very rapidly. In addition, it was found that base stations evoked positive implicit associations in a group of experts on mobile communication, neutral associations in a lay group, but negative associations in a group of base station opponents. In Chapter III, affect was measured using a free association technique which indicated what kind of images come to people's minds when they think of mobile phone base stations. Respondents from a large-scale Swiss sample mentioned predominantly negative images. It is noteworthy that respondents who attached high risks to base stations had different images than respondents who ascribed only low risk to base stations. In the subsequent chapter (Chapter IV) specific emotions were examined. It was found that anger strongly determined the benefit perception and the acceptance of mobile phone base stations; fear, in contrast, strongly influenced risk perception of base stations. Chapter V concentrates on public preferences for different base station sites. By applying a conjoint analysis, it was revealed that in comparison to other attributes, the location of the base station is of capital importance for citizens. Preferences for base station sites were also related to health beliefs, trust, and demographic variables. Finally, an experimental study (Chapter VI) demonstrates that participants who were provided with technical knowledge expressed more favorable base station siting preferences, i.e. those that would cause less exposure for the phoning population. The last section (Chapter VII) of this work synthesizes the results of all studies, and also addresses some limitations. In addition, central implications for research and practice will be derived.

Acknowledgment

Many persons supported me during the writing of this thesis, and I would like to take this opportunity to express my gratitude to a number of people who over the last three years have contributed in various ways to the completion of this work.

First, I would like to thank Prof. Dr. Michael Siegrist for his guidance, advice, and critical feedback throughout my dissertation. Likewise, I am grateful to Dr. Carmen Keller for her helpful suggestions and comments on my work. My thanks also go to Prof. Dr. Heinz Gutscher for supporting this dissertation project.

I would also like to thank my colleagues at the Consumer Behavior research group, ETH Zürich. Special thanks go to Dr. Marie-Eve Cousin, who introduced me to the topic. My thanks also go to Maria Rey for her administrative and organizational support, and also Sandro Bösch who helped me with some graphic issues. I also thank Maria Dickson, Lasse Wallquist, and Nina Tobler, who directly had to share and bear my dissertational ups and downs, and all other colleagues at CB who made Zürich a wonderful and inspiring place to work and live.

Likewise, this work would not have been possible without the support of my interviewers, who helped me to conduct the survey and some of the experiments, and the numerous voluntary participants in my studies. Furthermore, I thank Sebastian Hartmann, who drew my attention to *Homo Faber*.

I would also like to give my heartfelt thanks to my parents and my brother, who have always supported and encouraged me without a second thought in everything I have ever done.

Finally, I am also deeply grateful to Jan. Thank you for your feedback on earlier drafts of this manuscript, and more importantly, thank you for your patience, your boundless support, and all of your encouragement during my dissertation project.

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